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VOLUME I JUNE, 1917 NUMBER 2

TABLE OF CONTENTS

CH. G. GARRISON, A. BURKE and L. S. HOLLINGWORTH. The Psychology of a Prodigious Child 101
ROBERT M. YERKES. The Binet versus the Point Scale Method of Measuring Intelligence 111
JAMES BURT MINER. The Evaluation of a Method for Finely Graduated Estimates of Abilities 123
F. L. WELLS. Alternative Methods for Mental Examiners 134
A. A. ROBACK. Psychology as Applied to the Natural Sciences 144
E. H. FISH. Human Engineering 161
THE ATTITUDE AND THE REACTION OF THE BUSINESS MAN TO PSYCHOLOGY—
Editorial Introduction 175
H. C. METCALF. The Human Element in Business 175
G. G. MCCHESNEY. The Psychology of Efficiency 176
PAUL KREUZPOINTNER. Industrialism and Applied Psychology 180
WILLIAM STERN. Hugo Münsterberg: In Memoriam 186
BOOK REVIEWS AND NOTICES 189
SUMMARIES 194

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THE
JOURNAL OF APPLIED PSYCHOLOGY

VOL. I JUNE, 1917 No. 2

THE PSYCHOLOGY OF A PRODIGIOUS CHILD

By CHARLOTTE G. GARRISON, AGNES BURKE and LETA S. HOLLINGWORTH,
Teachers College, Columbia University

The pendulum of social and educational interest has swung in recent years so far toward the study and treatment of the mentally defective that the term "exceptional child" has been corrupted from its proper meaning, and has come to be popularly used as a euphemistic designation for the mentally deficient and neurotic. "Exceptional" properly means deviating either above or below the average, but ever since science has furnished us with the means of determining exceptionality in children, it is the undesirable and unprofitable deviate only who has claimed the attention of society.

It is extraordinary that educators have not turned long ago to the business of identifying and studying those children who deviate from the average in the direction of superiority. It is true that Terman,[1] as early as 1905, was interested in precocity, and he has published further work on the subject from time to time. In his recent book[2] he has especially stressed the desirability of studying superior children. Stern[3] also expressed an interest in such work, and a few fragmentary accounts have appeared from other authors. It is reported that Whipple has recently obtained a special fund for the experimental study of the education of gifted children, and Elisabeth Irwin, of the Public Education Association, has this year been instrumental in organizing a class of such children in one of the public schools of New York City. But the fact is that superior children have received so little attention as

[1] Terman, L. M. Precocity and Prematuration. *Am. Jour. Psych.*, 1905.
[2] Terman, L. M. The Measurement of Intelligence. Houghton, Mifflin Co., New York, 1916.
[3] Stern, W. The Supernormal Child. *Jour. of Ed. Psych.*, 1911.

compared with defective children, that parents now feel it as an insult when it is suggested that their child should be "tested!"

From time to time we hear through the newspapers of children who are alleged to possess extraordinary intellectual powers and abilities. "Infant prodigies" we call them. Such children as William James Sidis and Winifred Stoner are current examples. It is claimed for both of these children that their prodigious achievements are the result of special systems of education. So far as is known the intelligence of such children has not been quantitatively measured.

Biography gives us stories of juvenile prodigies like J. Stuart Mill and Thomas Macauley, who are said to have enjoyed the classics in their infancy, and who both lived to prove their genius by adult achievement. It is obvious that it would be of very great educational value if we now had mental measurements of those children who grew up to be men and women of genius. For example, if we had a scientific record of the mental status and development of J. Stuart Mill, of Thomas Edison, of Madame Curie, of Abraham Lincoln and of George Eliot up to the age of fifteen years, or if we knew the intelligence quotients of all the Nobel prize winners at the age of eight years, what guidance for educational practice might be contained therein!

As it is, we know practically nothing of those children who have become the intellectual masters of mankind. Were they superior children or ordinary children? Or, as is often alleged, were they backward children? At what age could their future possibilities have been predicted by the use of intelligence tests? What were their temperamental and moral characteristics? Were their abilities special or general? Were their interests symptomatic of the abilities that they were to display? To none of these questions can we give any answer at all. If educators should now begin to collect quantitative measurements of the intellects of all children who deviate from the norm in the direction of decided superiority, we should know in fifty or one hundred years from now whether and to what extent superiority in childhood is correlated with superiority of achievement in adult life. Science has already furnished us with a means of identifying exceptional children, and of measuring the amount of their exceptionality, so far as intelligence is concerned. If science within the next fifty years should furnish us with the means of prophesying adult achievement on the basis of the child's exceptionality, the history of human progress might be modified in ways of which we now can but vaguely guess. We should then be able to

select and cherish human genius without regard to race, sex or condition of economic servitude. We should preserve the impecunious boy from the dyspepsia or tuberculosis which waits upon bad food; we should not then, as now, guide the little girl with an intelligence quotient seventy-five per cent above the average to the dish pan and the carpet sweeper.

It is the purpose of this paper to record the psychological and physical measurements of a prodigious child and to give his personal history. This child is of that degree of exceptional intelligence possessed by but one child in more than a million. Thus it seems worth while to make the records detailed. There is no fear that such reports will multiply beyond reasonable limits, for only a few children of such ability are born in a single generation.

E——— is a boy eight years and four months of age. He was born June 17, 1908, and the psychological measurements were made on November 4, 1916. The circumstances that led to acquaintance with him were as follows. A child of exceptional intelligence was desired for demonstration before a class in the psychology and treatment of exceptional children in Teachers College, and this child was suggested on account of his remarkable school record. The consent of his parents was secured and the psychological examination was made before a class of about thirty students. These are of course not the ideal circumstances under which to perform a mental test for scientific record. The presumption would be that the audience would tend to reduce the child's performance, so that whatever error there may be from this source would be in the direction of making the child appear less exceptional than he really is. Of course no one knew beforehand that such a phenomenal record was about to be made; for had such an unusual result been expected this child would have been kept for examination under more favorable laboratory conditions.

General Intelligence. The Stanford revision of the Binet-Simon measuring scale was used for the determination of the child's mental level, and the examination was made by Dr. Hollingworth. The examiner began with the "ball-in-the-field" test. E—— responded at once with the superior solution, thus giving a preliminary cue to the quality of his mind, and the examiner proceeded immediately with the other tests at the twelve-year level of intellect. E—— passed all of the twelve-year tests with facility and ease, giving responses of excellent quality. From the twelve-year level the examiner then worked forward in all the higher levels through "superior adult." This is, of course, a long examination, and in view of the actual age of the child it was deemed best to give

the tests at two separate sittings, when it was seen that he would cover the whole upper range of the scale. The examination was therefore accomplished in two sittings of about fifty minutes each. The final record of E—— shows that he measures on the scale as follows:

	Yrs.	Mos.		Yrs.	Mos.
1	.....	.....	8	.....	.....
2	.....	.....	9	.....	.....
3	.....	.....	10	.....	.....
4	.....	.....	12	12	.....
5	.....	.....	14	.....	16
6	.....	.....	Adult	.....	15
7	.....	.....	Superior adult	.....	12
			Total	15	7

Since his actual age is eight years and four months and his mental age is fifteen years and seven months his I.Q. (Intelligence Quotient) is 187. On the curve of the distribution of intellect he stands eleven times the probable error removed from the norm, a position occupied by but one child in more than a million. He stands as far removed from the average, in the direction of superiority, as an idiot stands removed in the direction of inferiority.

An analysis of his performance shows that E—— has extraordinary appreciation of the exact use of words, and of the shades of difference between words. His vocabulary is about that of an average adult. He gave correct meanings for 64 words out of the 100 in the vocabulary test. His vocabulary thus includes 11,520 words. The score of the average adult is 65 words. Thus he just missed scoring on this average adult test. Samples of his definitions are as follows:

scorch—is what happens to a thing when exposed to great heat.
quake—is a kind of movement, not intended.
ramble—is a walk taken for pleasure.
nerve—is a thing you feel by,—for instance, cold.
majesty—a word used to address a king,—your majesty.
Mars—is a planet.
peculiarity—is something you do that nobody else does.
mosaic—is a picture made of many small pieces of marble.
bewail—is to be extremely sorrowful.
tolerate—is to allow others to do what you don't like yourself.
lotus—is a kind of flower.
harpy—is a kind of half-bird, half-woman, referred to in Virgil.
fen—is a kind of marsh.
laity—is *not* clergy.
ambergris—it comes from a whale.
straw—the stalk of a cereal plant.
lecture—someone giving a very long talk about something to an audience.

E—— also has a prodigious ability for comprehending and formulating abstract ideas, and for working with symbols. He gave the differences between the abstract concepts under "average adult," test 3, as follows:

a. Laziness and idleness. Laziness is that you don't *want* to work; idleness is you *can't*, for a while.
b. Evolution and revolution: Evolution is making things from the beginning; revolution is changing them.
c. Poverty and misery: Poverty is when you don't have anything; misery is how you feel when someone insults you.
d. Character and reputation: Character is what he *really* is; reputation is what they *think* he is.

He succeeded in reversing the clock hands three times without any error, in less than a minute for each trial. He was able to reproduce the thought from the selection beginning "Many opinions have been given about the value of life," as well as a superior adult. He solved the three mental arithmetic problems under XIV, 5 in less than a minute each, absolutely without error. These performances serve to illustrate his precocious power over symbols and over abstractions. His attention, concentration and capacity for sustained effort are illustrated by the fact that he was able to repeat five digits backwards twice out of three trials absolutely without error, before a class of thirty adults. His memory span for digits repeated forwards is at least 8. (He was not tried with more than 8 digits.)

During the examination he showed neither embarrassment nor any tendency to "show off." He was alert, interested, and gave his attention strictly to the business in hand. He always knew when he had failed on a test, and gave up with great reluctance. For example, he was unable to solve the problems under XVIII, 6, in the time allotted; but he carried these data away in his head, and held to them tenaciously till he had solved the problems. In several instances after he had given his reply he recast it in better form. In short, he exemplified in remarkable degree all of the characteristics which Binet finally chose as symptomatic of intellectual power, i. e. (1) the ability to take and maintain a given direction; (2) the capacity to make adaptations for the purpose of obtaining a desired end; and (3) the power of auto-criticism.

Special Tests. Following the procedure described by Seashore, and using the set of forks recommended by him, E—— was tested for pitch discrimination, being given seven trials with the whole series of forks. His record was as follows, # meaning a correct answer and — meaning a false one.

	Vibration differences									
Series.....	30	23	17	12	8	5	3	2	1	.5
1.....	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
2.....	✓	✓	—	✓	✓	✓	✓	✓	—	.
3.....	✓	✓	✓	✓	✓	—	✓	—	—	✓
4.....	✓	✓	✓	✓	✓	—	✓	—	✓	—
5.....	✓	✓	✓	✓	✓	✓	✓	✓	—	—
6.....	✓	✓	✓	✓	✓	—	✓	✓	✓	✓
7.....	✓	✓	✓	✓	✓	—	✓	—	✓	✓

His threshold for pitch discrimination would thus seem to be not greater than five vibrations, and would probably be found to be as low as three if a more complete test were possible. This is a very good record, according to Seashore's standards.

E—— gave free associations to the first 50 words of the Kent-Rosanoff list of words, both stimulus words and responses being oral. The stimulus words and responses follow.

Stimulus	*Response*	*Stimulus*	*Response*	*Stimulus*	*Response*
table	dinner	smooth	surface	needle	slim
dark	night	command	army	red	color
music	soft	chair	cushion	sleep	fast
sickness	fatal	sweet	sugar	anger	sick
man	tall	whistle	blew	carpet	bagger
deep	ocean	woman	lady	girl	pretty
soft	couch	cold	coal	high	mountain
eating	dinner	slow	train	working	people
mountain	snowcapped	wish	I	sour	lemon
house	brick	river	Hudson	earth	big
black	dog	white	color	trouble	great
mutton	beef	beautiful	dress	soldier	brave
comfort	your	window	glass	cabbage	green
hand	dirty	rough	surface	hard	surface
short	man	citizen	U. S.	eagle	swift
fruit	orange	foot	bare	stomach	ache
butterfly	moth	spider	black		

At once after giving some of these responses he explained why he had given them. Thus he explained that "carpet-bagger" had to do "with Civil War history." After giving "beef" in response to "mutton" he smiled and said, "That's a joke, isn't it?" When asked why he thought it a joke he replied that he thought very few people would give that answer. After the test he was told that 97 people in a thousand gave "beef" in response to "mutton" and he at once said, "Ten per cent, that's not so *very* many."

It was impossible for lack of time to give the complete list of 100 words, usually given in this test. Using the 50 as a basis of calculation, 78% of the responses are "common responses" in the Kent-Rosanoff sense of the word, a number

of common responses which children do not usually show until after the age of 10 years. His "median of community" (a measure not yet standardized for age levels) is 1.4%.

He was given the Pintner form of the Knox Cube test, and achieved 11 of the 12 lines arranged by Pintner. The average record for the 16 year old is only 8 lines, and this is the highest level for which the test is yet standardized.

The usual Tapping Test was given, tapping continuously with the right hand, with the stylus, for one minute. The record was 239 taps only, which is lower than the average 8 year old record.

Given three minutes in which to make up words out of the letters a-e-i-r-l-p, he made the following,—a, rip, pie, lie, ale.

He was given thirty minutes in which to put together the pieces in the Stenquist Construction Box II, and was not able to put any of the pieces together. He began at one end of the box, examined each set of materials in turn, tried to put them together in an indiscriminate way, put them back and went on to the next set of materials. He remarked, "I don't seem able to put any of them together. It seems that all I can do is to find out what each of the things is for." He recognized that various sets of pieces were "a mouse trap," "a lock," "a bell," etc., but made a zero score from the point of view of construction. At the end of twenty minutes he gave up and turned away from the materials.

It is interesting to compare the child's record in construction tests, and his comments regarding these tests, with his school record in *industrial arts* and *fine arts*. E—— receives the best possible rating in industrial arts because he has keen insight into *processes*, and can explain how to construct a mechanism or perform an operation clearly and minutely, though he is unable to carry out his own instructions. For instance, he can tell exactly *how to make* a boat, but cannot *make* the boat himself. There is thus an interesting distinction here between "constructive ability" and "manual dexterity." Similarly, in fine arts E———has many ideas for decorative schemes, but he is unable to execute these ideas *with his hands*.

Developmental History.[4] E—— was the fourth child, three girls having been born before him, all having died. Birth was difficult. He was bottle fed. His parents were both

[4] The developmental history and history of personal health were elicited from the mother, who, being a physician, is especially competent to speak on these points. The family history, and the facts respecting his extra-school linguistic achievements were also given by the mother.

in middle life at the time of his birth. He cut his first tooth at eight months,—a lateral incisor. He walked at thirteen months. Up to two years of age E—— did not say a word. He then began to talk, and before he was three years old was able to read such books as "Peter Rabbit." Conversation with him was carried on in German, French, Italian and English equally. When he did begin to talk he could say all the words he knew in these four languages. His health has been exceptionally good from infancy. He has had no disorders or diseases except measles, and an occasional attack of indigestion. He is exceptionally free from colds.

Physical Measurements	E— Oct 30, 1916	Age, 8 yrs. 4 mos., average
Weight	89.3 lbs.	70.5 lbs.
Height	54.3 in.	54.3 in.*
Girth of chest	31.8 in.	25.6 in.
Girth of chest, expanded	32.4 in.	26.8 in.
Lung capacity	100.0 cu. in.	112.0 cu. in.
Strength, right forearm	30.9 lbs.	39.7 lbs.
Strength, left forearm	22.0 lbs.	37.5 lbs.

* These averages are for a boy of this age *and height*. The average *height* for a boy of 8 yrs. 4 mos. is 49.7 inches. The measurements are transcribed from the gymnasium records of the school where E— attends.

It will thus be seen that E—— is considerably larger than the average boy of his age. He has clear, well-molded features. The child does not like physical exercise of any kind, but has had special attention along this line, such as lessons in swimming, dancing and horseback riding. He sleeps eleven hours, and goes to sleep immediately upon going to bed.

School Achievement. E—— went to kindergarten from the age of three years to the age of five years. From five to six he was out of school on account of school organization (he could not be accepted in the first grade). From six to seven years of age he attended an open air, ungraded school, and did the work of the second to the fourth grades. From seven to eight years he was in the fourth grade in regular school classes, and at present, at the age of eight years, he is in the sixth grade. He is thus three full years accelerated in school grading, according to the age-grade norms, but is still three years retarded in school grading according to his mental age. (Terman makes special note of the fact that superior children are almost invariably retarded in school grading according to mental age.) His mother states that under private tutors E—— has covered the work of the seventh grade and nearly all the work of the eighth grade. His school standing

on his last report was as follows. The highest attainable rating is 1; the lowest, 4.

Courtesy.....1	Composition.....2	Penmanship.....3
Promptness.....1	Grammar or	Industrial Arts....1*
System.....1	Language.....2	Fine Arts.....4*
Spelling.....2	Mathematics.....3*	Music.....2
Reading or	Geography.....1	Physical Ed.....4
Literature.....1	History.....1	Science.....1

* In industrial arts credit is given for *knowing* industrial processes. as well as for ability to carry out the processes, whereas in fine arts credit is given for manual dexterity only. Private tutors grade E— as 1 in mathematics.

In addition to his regular school work the child has covered the following special work in language and mathematics, either with a tutor or with his mother: *Geometry; algebra,* as far as equations; *Latin,* partial knowledge of the four declensions, (he has been taught by the direct, informal method, and reads easy Latin); *Greek,*—worked out the alphabet for himself from an astronomical chart, between the ages of five and six years; *French,* equal to about two years in the ordinary school; *German,* ordinary conversation; *Spanish,* attended class with his mother,—reads and understands; *Italian,* reading knowledge, simple conversation; *Portugese,* asked his mother to take this language at the Columbia summer school because he could not be registered himself; *Hebrew,* a beginning; *Anglo-Saxon,* a beginning. In *Astronomy* he has worked out all the constellations from MacCready, and displays a very great interest in this subject. One evening this winter he noticed a new planet near the Twins. He said it was Saturn, but his mother thought it was Mars. E—— went home, worked the position out from the chart, and found it to be Saturn. He has a great interest in nature wherever found, and is already able to use Apgar intelligently. His writing is not equal to his other accomplishments. He is very slow at it and for this reason dictates most of his "home work" to a stenographer. History is his chief and absorbing interest among school subjects.

Social Habits, Tastes, etc. E—— does not care to play, and would never do so unless forced. He is very impersonal and agreeable in his attitude toward other children. His chief diversion is reading and his favorite book at present is *Ivanhoe.* He has no hobbies. In the spring of 1916, after careful and thoughtful preparation, he joined the Episcopal church. His desire is to be a minister and become a missionary. When asked what he would consider the most fun in life he replied,

"To have statistics of my imaginary country." This country is on Venus. It is inhabited by people and has a navy like ours. E—— does not volunteer much information about his interests. All of these items had to be elicited by questioning.

Family History. Father: College graduate. Produced a Latin play, which was given in a Boston theatre, while still an undergraduate. Since graduation has maintained a keen interest in educational matters. Organized a special library of insurance in Boston, which is now used as a reference library all over the world. Is at present engaged in business. Has written many books. Is a university lecturer on insurance. Has served on many important city commissions.

Mother: Holds the following degrees: A.B., Boston University; A.M., New York University; M.D., Medical College (now merged with Cornell); LL.B., New York University Law School. Post-graduate study, Johns Hopkins one year and Germany six years. Special study in bacteriology and pathology in Germany and Paris. Has done research for Rockefeller Institute in bacteriology of milk, and has published notable research in this field. Publication awarded a medal at the St. Louis Exposition. Sent as a delegate to medical congresses in Rome and Moscow.

In the present state of our knowledge, no prognosis as to the future achievements of such an exceptional child can be advanced on a scientific basis. The data here collected are of significance in that they show how far it is possible for a child to vary from the norm in the direction of superior intelligence. They also suggest the value of studying the psychology of precocious children, so that we may advance our science to a point where we shall be able to prognosticate concerning them.

THE BINET VERSUS THE POINT SCALE METHOD OF MEASURING INTELLIGENCE[1]

By ROBERT M. YERKES

Ladies and Gentlemen: I have several important reasons for wishing to discuss this particular methodological aspect of psychology at this time and in this institution. Human engineering on the basis of mental measurement is progressing so rapidly that we have cause to doubt the adequacy of our methods. We face the fact of the almost universal application of such methods of measuring intelligence as the Binet and Point Scales, yet these measuring instruments are extremely crude and at the same time obviously improvable. It is equally our duty and our opportunity to so modify or replace them that our results shall steadily increase in accuracy and reliability. As it happens the three men who have done most to adapt the Binet scale to American needs and to improve it—Kuhlmann, Goddard, and Terman—as students in this institution have enjoyed the privilege of working under the guidance of the foremost of genetic psychologists.

The profound significance of natural science for civilization is no longer seriously questioned. The world war has convinced us, on the one hand, that the physical sciences are far in advance of the biological and social sciences, and on the other hand, that there is imperative need of systematic attention to the latter group of sciences. Many of us are wholly convinced that the future of mankind depends in no small measure upon the development of the various biological and social sciences. Among these physiology, psychology, and sociology are preëminently important. We must, I submit, if we are adequately to meet after-war demands and improve the opportunities which will then be offered us, strive unceasingly for the improvement of our methods of mental measurement, for there is no longer ground for doubt concerning the practical as well as the theoretical importance of studies of human

[1] Read by invitation of President G. Stanley Hall before his Psychological Seminary, March 19, 1917.

Being Psychopathic Hospital Contributions Whole Number 171 (1917.5). The previous contribution was by Rose S. Hardwick (1917.4), entitled "The Weighting of Point Scale Tests." To be published in *Journal of Educational Psychology.*

behavior. We must learn to measure skilfully every form and aspect of behavior which has psychological and sociological significance. Such are a few of my reasons for wishing to compare critically the two most prominent methods of measuring intelligence.

These methods are too well known to demand historical introduction. Although each is at present widely used, they differ radically in principle and might reasonably be expected to yield strikingly different results. Measurements of intellectual forms and aspects of behavior are of two principal sorts: (1) the scale or group-test procedure, and (2) the single or specific functional measurement. Both the Binet and the Point Scale are groups of tests. It is essential for us, at the beginning of this discussion, to note that for scientific purposes the ideal method of measuring behavior is the specific functional test. Scales are technological tools which have been devised to satisfy certain practical demands. The inevitable direction of development in our mental measuring is toward the graded, standardized, highly accurate, specific test or method. Groups of tests or, as it is convenient to call them, scales, are likely to persist and multiply because they will continue in increasing measure to meet important human needs.

But even now we may appropriately ask, should both the Binet and the Point Scale methods be further developed and improved, should the one or the other be wholly abandoned, should both be given up and in their place a new type of scale embodying perhaps the best principles of each be created, or, as yet another possibility, should the grouping of tests be abandoned and recourse be had to highly developed single functional tests?

At the risk of seeming to reverse logical procedure, I wish at once to suggest my tentative answer to these questions, for after all, this discussion may be endured only for the sake of the conclusions. I believe, in the first place, that scales or groups of tests can not well be dispensed with. I further believe that we should concentrate our efforts on the development of reliable methods of measuring the various types and aspects of practically significant human behavior. In order to fulfill the conditions which these two conclusions impose upon us, I wish to suggest the desirability and the feasibility of developing a scale for the measurement of intelligence which shall at once combine the safe and serviceable principles of the Binet and Point Systems and improve upon them. This new scale should take account alike of the qualitative and quantitative aspects of behavior. It should consist of carefully selected and graded tests. It should be standardized in such

wise that its constituent parts might be used independently, thus serving the purpose of specific functional tests. It should be possible to embody in a single scale all the advantages of existing methods of measuring intelligence, and even to add to them.

There are those who insist that the Binet and Point Scales are not essentially different. It has even been said, carelessly, that the latter is merely a revision of the former method. Such statements are surprising indeed in view of the facts to which I must now call your attention.

Careful analysis of the two scales indicate that they differ more or less radically on three fundamentally important points: (1) the method of selecting or choosing their constituent parts (tests of intelligence); (2) the method of standardizing their tests or combinations of tests; and (3) the method of measuring and expressing the subject's response.

Method of Selecting Tests

The various tests or methods which make up the Binet scale are selected in accordance with the number of successes or failures at various ages. If a particular test is passed by a certain percentage of individuals at eight years of age, by a lower percentage at seven years, and a higher percentage at nine years, it is, other things being equal, deemed suitable for the eight-year group. It thus appears that tests are chosen in the light of success or failure and arranged in age groups. This method apparently rests upon the assumption that important forms of behavior appear at various times during infancy, childhood, and adolescence. By contrast, the methods which constitute the Point Scale are chosen from the standpoint of functions to be measured, and without regard to their particular relations to the stages of human development. It is assumed in the construction of the Point Scale that all of the important types of intellectual function are present in early childhood and develop more or less rapidly. If this be true, tests or measures for all fundamental forms of intellectual behavior should be available no matter what the age of the subject. Briefly put, the Binet is an age-scale based upon the assumption of *appearing functions;* the Point Scale is a functional scale, based upon the assumption of *developing functions.*

Genetic psychology justifies the statement that all important types or classes of intelligent behavior are represented in the human action system by the end of the third year of postnatal life. Thereafter new acts belonging to the same types continue to appear for some years and all tend to become complexly related to one another and to innate reactive tendencies.

As one result of the heterogeneity of tests within the Binet scale groups, the measurements made on individuals of different ages are not strictly comparable, for the obvious reason that different forms or aspects of behavior have been measured in the two cases. In support of this statement, I need only contrast the tests which make up the five-year and eight-year Stanford-Binet groups. In the five-year, there appear (1) comparison of weights; (2) naming of colors; (3) aesthetic comparison; (4) definition by use, or better; (5) patience, or divided rectangle; (6) three commissions. The eight-year group consists of (1) the ball and field test; (2) counting backward, 20-0; (3) comprehension of questions; (4) giving similarities of two things; (5) definition superior to use; (6) vocabulary. Even the most enthusiastic believer in the Binet scale and method cannot hope to maintain the thesis that at each or even at any two ages precisely the same forms or aspects of human behavior are measured. In the Point Scale, it is the ideal, thus far only partially realized, to measure the same and the most fundamental features of behavior at every age, and thus to obtain strictly comparable results from year to year.

Method of Standardization

The Binet Scale is internally standardized; the Point Scale, externally. For the former method, the process of selecting tests according to percentage of passes and of grouping them according to age constitutes standardization. The result of this method of selecting and standardizing tests is an inflexible scale, which, however, accurate it may be for the race, social stratum, or sex, for which it was constructed, cannot possibly yield reliable results when applied to widely differing groups of individuals. For this reason an internally standardized method of measuring behavior is defective.

The Point Scale may be described as externally standardized because the selection and arrangement of the tests have nothing to do with the norms which as standards of judgment are used in the evaluation of results. With the application of the Point Scale to increasing numbers of individuals, the norms, whether for age, sex, race, educational or social status, become increasingly numerous and reliable, and the value of the method correspondingly increases. In order to use the Point Scale profitably for a new race, or social group, it is necessary only to make a sufficient number of examinations to yield reliable norms. They immediately become standards of judgment. The method does not have to be revised. Thus it is

evident that where the Binet Scale is inflexible, the Point Scale is flexible and universally applicable.

Method of Measuring and Expressing Response

The third fundamental difference mentioned above appears in the method of measuring and expressing reaction. The Binet Scale supplies judgments of success or failure. These have been described as all-or-none judgments. From the scientific point of view, they are but rough approximations to the desired and desirable measurement, since they are rather the forerunners of quantitative statements than themselves quantitative. In the Point Scale, judgments are of the more-or-less sort. In other words, there is not a judgment of "pass" or "fail," but instead, there is awarded a particular amount of credit, which supposedly varies in correspondence with the character or amount of response. The Binet measurement is neither qualitative nor quantitative, but marks the transition. The point-scale measurement is distinctly quantitative. But in so far as the ideal of point-scale construction is achieved, the method takes account of qualitative as well as quantitative differences in response. The importance of this contrast in the methods which we are considering has, I think, been fully appreciated by very few critics. It is, in fact, the difference between a relatively unscientific procedure and one which is striving to fulfill the essential requirements of scientific method.

There is, moreover, a profoundly important corollary. The type of measurement which the Binet Scale yields is amenable to statistical treatment only in a very restricted way. Thus the mean or standard deviation, the probable error of mean or deviation, the co-efficient of correlation with its probable error either cannot be obtained at all for Binet judgments or are of slight value because of the non-quantitative character of the judgments. By contrast, point-scale measurements can be statistically treated in all the varied and biologically significant ways. In my opinion, it is primarily because of this merit, that the Point Scale has gained so rapidly its wide recognition and use. The advantage which it has, from the statistical standpoint, over the Binet method is tremendous, and only those persons who are unfamiliar with the essentials of scientific method or incapable of appreciating the value of statistical data fail to note and respond to this difference. The Point Scale because of this characteristic is at once a technological tool and an instrument of research. The Binet Scale is technologically useful, but possesses little research value.

Weighting of Tests

It has been objected by some critics, that the point-scale system is unsatisfactory because the various tests are weighted in the light of no definite scientific principle. This adverse criticism I accept as valid, but in fairness it must be pointed out that it applies with equal force to every other scale whose several measurements are averaged or in any other way combined. Thus, for example, the Binet Scale gives equal weight to all the tests of a given age group, despite the fact that they may be concerned with utterly different modes or aspects of response whose practical importance in the individual's life must vary extremely at any given time as well as with age and the correlation of which with general intelligence is known to vary greatly. I submit, not in defense of the point-scale procedure but merely in fairness to it, that the Binet Scale is quite as much in need of a sound and systematically applied principle of weighting as is the Point Scale.

But ground for defense is not utterly lacking. The point-scale tests were not weighted in haphazard fashion. Instead, varied experience in actual examining, coefficients of correlation with general intelligence and of one type of measurement with another were considered and the weightings apportioned as carefully as was possible in the absence of any single and obviously satisfactory principle. The principle which we propose to apply in the further development and perfecting of the point-scale system is that of weighting in correspondence with the correlation of a particular measurement with general intelligence, or rather with the point-scale score.[2] The higher the coefficient of correlation, the greater the credit for a particular test. This principle we are trying out. If it stands our tests, we shall have met our critics squarely, and at the same time shall have gone beyond the Binet Scale in regard to scientific qualifications.

Chronological Versus Physiological Age

Yet another important consideration remains to be mentioned before an attempt is made to sum up the contrasting characteristics of the two methods. The use of chronological age in connection with mental age as a basis for the statement of individual status is scientifically without justification. The rapidity of growth and of the maturing of organic structures and functions varies greatly for races, for individuals, for the sexes, for diverse conditions of nutrition and of health. It

[2] Hardwick, R. S. The weighting of point scale tests. (To appear in *Journal of Educational Psychology.*)

is consequently unsafe to compare the status or the achievement of two individuals on the basis of their years, months, or days of postnatal existence. That psychologists will ultimately be forced to admit this fact and to abandon or modify their use of chronological age and of mental age in connection with measurements of intelligence is my conviction. Physiological age should be determined and with it the varied results of measurement should be compared or correlated. This means that in case of each examination there should be stated not only the chronological age of the individual but also the physiological age as indicated by carefully chosen measurements of status of the organism and of functional capacity, and finally, the specific results of varied mental measurements in comparison with the expected results or norms for the appropriate physiological age.

By way of summary, the significant points of contrast between the Binet and the Point systems are exhibited in parallel columns.

	Binet Characteristics	*Point Scale Characteristics*
(1)	Multiple-group, age or year scale	Single graded-test scale
(2)	Selection by relation of successes to age	Selection by function measured
(3)	Varied, unrelated, ungraded tests	Each test so graded as to be available for wide range of ages
(4)	Internally standardized and inflexible	Externally standardized and flexible
(5)	All-or-none judgments	More-or-less judgments
(6)	Qualitative	Quantitative
(7)	Measurements only slightly amenable to statistical treatment	Measurements wholly amenable to statistical treatment
(8)	Tests weighted equally	Tests weighted unequally
(9)	Implicit assumption, that of appearing functions	Implicit assumption, that of developing functions
(10)	Measurements for different ages relatively incomparable	Measurements for different ages relatively comparable

The foregoing discussion has been based wholly upon the latest and most improved form of the Binet method,—the Stanford revision, and upon what the writer knows to be the ideals in point-scale construction rather than the actual achievements as visible to those who know only the original or preadolescent Point Scale described in "A Point Scale for Measuring Mental Ability." All earlier forms of the Binet method are neglected because their imperfections are more numerous and more serious than those of the Stanford Scale. It may therefore be assumed that such criticisms as are applicable to the latter apply with at least equal force to the former. On

the other hand, it must be emphasized that the claims which I make for the point-scale system are not wholly justified by the present status of the method. I have ventured to draw the contrast sharply because of my belief that they will be justified by the results of work on the method which is now well advanced at the Psychopathic Hospital, Boston.

In one respect the Stanford revision appears to be especially weak. It includes a number of tests (vocabulary, fables, arithmetical reasoning, and definitions, for example), which are highly dependent upon education. Were it not for this fact, which shortly becomes apparent to any experienced psychological examiner who attempts to use the method, Terman's extension of the scale by the addition of tests for adolescents and adults would be a very great advantage.

Analysis of the Stanford-Binet Scale

In connection with this comparison of the two systems of measurement, I have attempted to analyze the Stanford revision of the Binet Scale from the points of view of functions measured and the distribution of measurements among the various age groups. In all, ninety tests appear in the Stanford scale. Of these, seventy-four make up the twelve age groups, while sixteen stand as alternates. There are fifty-five different tests, that is, tests so obviously different in constitution and mode of response demanded that they may not be grouped as equivalents. These may further be reduced to the following twenty-five functional groups on the basis of similarity of responses measured.

Stanford-Binet Tests Grouped According to Similarity of Responses Measured

1. Recognizing and naming objects: naming objects, stating sex, stating name, naming colors, stating age, naming coins, naming days of week, naming months of year, morning or afternoon, indicating right and left.
2. Response to pictures.
3. Memory for: syllables, sentences, digits forward and backward, designs, ideas.
4. Discrimination and comparison of lines, weights, forms.
5. Counting objects and fingers.
6. Counting backwards.
7. Copying geometrical forms.
8. Comprehension of questions.
9. Aesthetic judgment.
10. Defining terms.
11. Patience and form board.
12. Executing commands.
13. Discovery of missing parts.
14. Tying bow-knot.

15. Giving differences or similarities.
16. Ball and field.
17. Vocabulary.
18. Dictation.
19. Mathematical reasoning: making change, value of stamps, box problem, ingenuity test.
20. Sentence construction: three words in sentence, dissected sentences.
21. Visual imagination: clock test, Binet paper cutting, rhymes, absurdities.
22. Fables.
23. Induction test.
24. Code.
25. Free association.

Now it might be supposed, prior to examination, that some sort of test for a particular variety of response would appear in each age group, but this is not the case. Instead, the constructors of the scale seem to have systematically avoided not only repetition of a particular test, but even in the main, its repetition in increasingly difficult form. Thus, for example, the well-known Binet test of response to pictures by enumeration, description, or interpretation, appears in the age groups three, seven, and twelve. It does not appear in any of the others nor is there any test which is strictly comparable with it in any one of the remaining nine groups of tests. The definition test which, if it has any practical value, might be supposed to be equally serviceable for all ages, is used for the ages five, eight, twelve and sixteen, and for those alone. Why for these particular ages instead of for any other or others between three years and intellectual maturity is difficult to imagine. Or again, the Stanford test, new to the Binet system, of repeating digits backward appears as an alternate for age seven and as a regular test for ages nine, twelve, sixteen and eighteen. Why, the critical psychologist may well ask, is it not equally serviceable for the ages ten and fourteen? And why, if one chooses to carry this sort of question to its logical conclusion, should not the test be used for all ages from the early stages of linguistic development to intellectual maturity?

As we follow through the list of fifty odd tests which make up this measuring scale, we observe that the number of groups in which a particular test appears tends to diminish. The infantile or childhood tests are many of them repeated in two, three, or even as many as five or six age-groups. But the tests of more complicated or more mature types of response tend, as the accompanying table shows, to be used in only a single group. The only striking exception to this rule is the vocabulary test, which finds place under the ages eight, ten, twelve, fourteen, sixteen, and eighteen years.

LIST AND DISTRIBUTION OF STANFORD-BINET TESTS

Name of Test	*Groups in Which Test Appears*
Indicating parts of body,	III,1.
Naming objects,	III,2.
Response to pictures,	III,3; VII,2; XII,7.
Stating sex,	III,4.
Stating name,	III,5.
Repeating syllables,	III,6; IV,al.; VI,6; X,a12; XVI,al.1.
Repeating digits forward	III,al.; IV,6; VII,3; X,al.1; XIV,al.; XVIII,3.
Repeating digits backward,	VII,al.2; IX,4; XII,6; XVI,5; XVIII,5.
Comparing lines,	IV,1.
Comparing weights,	V,1.
Discriminating forms,	IV,2.
Counting pennies,	IV,3; VI,3.
Copying geometrical forms,	IV,4; VII,6.
Comprehending questions,	IV,5; VI,4; VIII,3; X,5; XVI,al.2.
Naming colors,	V,2.
Aesthetic judgment,	V,3.
Defining terms,	V,4; VIII,5; XII,2; XVI,3.
Patience,	V,5.
Executing command,	V,6.
Stating age,	V,al.
Indicating right and left,	VI,1.
Missing parts,	VI,2.
Naming coins,	VI,5; VIII,al.1.
Morning or afternoon,	VI,al.
Number of fingers,	VII,1.
Tying bow knot,	VII,4.
Giving differences,	VII,5; XIV,3.
Naming days of week,	VII,al.1.
Ball and field,	VIII,1; XII,3.
Counting backwards,	VIII,2.
Giving similarities,	VIII,4; XII,8.
Vocabulary,	VIII,6; X,1; XII,1; XIV,1; XVI,1; XVIII,1.
Dictation,	VIII,al.2.
Giving date,	IX,1.
Arranging weights,	IX,2.
Making change,	IX,3.
Three words in sentence,	IX,5.
Rhymes,	IX,6.
Months of year,	IX,al.1.
Value of stamps,	IX,al.2.
Absurdities,	X,2.
Memory for designs,	X,3.
Reading and report,	X,4.
Free association,	X,6.
Form board,	X,al.3.
Dissected sentences,	XII 4.
Fables,	XII,5; XVI,2.
Induction test,	XIV,2.
President and king (included under giving difference).	
Problems of fact (included under comprehension of questions).	
Mathematical reasoning,	XIV,5.
Clock test,	XIV,6.

LIST AND DISTRIBUTION OF STANFORD-BINET TESTS—*Continued*

Name of Test	*Groups in Which Test Appears*
Box problem,	XVI,4.
Code test,	XVI,6.
Binet's paper cutting,	XVIII,2.
Memory for passage,	XVIII,4.
Ingenuity test,	XVIII,6.

This analysis of the Stanford scale serves two purposes,—first, it exhibits the haphazardness of distribution of a given test, the lack of any scientific principle, so far as the placing of a test in particular groups is concerned; and second, it indicates the entire absence of the functional principle in the selection of tests for a particular group.

In view of these characteristics of the Stanford scale, it seems pertinent still further to emphasize the idea of gradation within a given test or measure of behavior. Assuming, as genetic studies certainly warrant us in doing, that the fundamental forms of behavior are present by the end of the third year in their initial stages, it seems logical and scientifically necessary to argue that we should devise methods of measuring these forms of behavior as they develop, and that the most natural and most feasible way to do this is to select a method which can be applied, according to a gradation scheme, to all stages of development. For example, the test of repeating digits may be increased in difficultness without end. It may be applied alike to the child of three and the intellectually mature individual. It may be graded almost perfectly by the addition of single digits. The initial form of the test may require merely the repetition of a digit after the examiner. The most difficult form may, instead, require the repetition of ten digits. Or, the test of response to pictures may be so devised and developed as to be clearly applicable from early childhood to maturity. It needs only a number of carefully selected pictures arranged according to difficultness of description and interpretation. The child of three years may be required merely to indicate certain objects in the pictures, as named by the examiner. The child of four may be required, instead, to name these same objects. Still later, more complete enumeration of the constituents of the pictures may be expected; then description, and interpretation increasingly full and exact with increasing age. Finally, there would be required, as an adequate form of response, correct interpretation and fair to excellent description.

While it may not be assumed that precisely the same forms or aspects of behavior are measured by this test throughout its age range, it is at least evident that more nearly com-

parable results may be obtained by using the same materials for different ages than by using diverse and heterogeneous materials and procedures.

Neither the Point Scale nor the Binet Scale is perfect or ever will be. But from their ashes may arise a new scale infinitely superior to anything Binet or any of his successors have imagined. I believe that the method of graded tests whose indices of correlation with one another and with varied measures of efficiency in living are definitely known, will steadily gain ground; that the gradation as gradually perfected will lead to increasingly accurate standardization; that there will accumulate reliable and varied norms for the guidance of the inexperienced examiner; and that shortly our scales for mental measurement will consist of independently graded and standardized tests which can be used either alone for the measurement of particular response or in such groups as need dictates.

The next step forward I imagine as a scale in which vertical instead of horizontal divisions will indicate age lines. It will consist of a score or two of thoroughly proved and approved methods of measurement, each so devised that it may be applied at any stage of development. Were there twelve steps or grades of difficultness in each test, then the examiner would begin with the first grade for the three-year-old; with the fifth grade for the eight-year-old; with the ninth grade for the twelve-year-old. Not the scale, but its constituent part, the test, would be marked for convenience of use by age lines. The lines consequently would be vertical instead of horizontal!

THE EVALUATION OF A METHOD FOR FINELY GRADUATED ESTIMATES OF ABILITIES[1]

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Estimating abilities may be merely skirmishing in research, but the attack of the main army is often wisely or foolishly directed as a result of the skirmish. The technique of estimating accordingly assumes an essential place in psychological procedure. Any improvement in the discrimination or reliability of estimates promises to meet urgent needs, not only in the employment office but whenever questions of admission or promotions are considered in the school room, the store, the factory, or the business office.

Our immediate problem was connected with the employment office at the Carnegie Institute of Technology, which recommends students and graduates for positions ranging from civil engineer to actress, from plumber to musician, from architect to teacher. Can the scholarship records be supplemented by sufficiently reliable and significant ratings of personal traits to be of use in recommending these young people for work?

Beginning with the problem of estimating the traits of those about to graduate from the institution, we were at once confronted by the fact that all the seniors were not intimately enough known by one person to make it possible to have an order of merit for the whole class in a college arranged by the same person. This is a frequent problem in estimation. Thorndike has attacked it by a method of combining the judgments of numerous judges.[2] His method, however, requires that each individual in the final order of merit be compared by several judges with those on either side of him, a condition we could not fulfill.

We hoped to obtain sufficient accuracy by assuming that the average senior class in the various courses within the same school had roughly the same distribution of ability. On this assumption a single order of merit might be obtained for the

[1] Substantially as read before the American Psychological Association, December, 1916.

[2] E. L. Thorndike. The Technique of Combining Incomplete Judgments of the Relative Position of N Facts by N Judges. *J. of Phil., Psychol.*, etc., 1916, vol. 13, 197-203.

seniors of each school, provided that some systematic method of grading could be discovered which would be used in approximately the same way by the different judges.

The method which we tried out is indicated by the sample rating blank shown in Fig. 1. At least four of these blanks were prepared for each student in the senior classes and they were sent to members of the faculty who were supposed by the administrative officers to be best acquainted with the particular students. Three out of the four had come in contact with the students in either the laboratory or shop, which afforded them a better opportunity for judgment than is possible in many institutions. The fourth judge was a teacher in one of the academic subjects. In order that no member of the faculty should be burdened we limited the number of students to be graded by any one instructor to about a dozen. About 70 judges graded sub-groups of the 140 seniors.

One feature of the method consisted in grading the person by means of a dot placed on a line. This plan of placing a dot on a line was found in a blank prepared by the B. F. Clark Teachers Agency of Chicago. A somewhat similar plan with five divisions from 0-100, without definition of the meaning of the divisions or of the standard group, was tried at one time by the Appointment Committee at Teachers College, Columbia University. The method was adapted to our purpose by substituting divisions into fifths of a group instead of the divisions "superlative, excellent, satisfactory, fair and poor" which were used on the teachers' agency blank. Psychologically the use of a dot on a line seems to have a decided advantage over the percentage method, which it most closely resembles, in that it gets rid of the habit of thinking that different percentages have qualitative significance as indicating passing or excellent grades.

The blank embodies four fundamental principles for securing systematic estimates which are here combined for the first time, so far as I know. They summarize the result of much of the systematic work which has been done in this field in recent years. (1) The person is rated relative to the members of a defined group which is known by the judges and is used as a standard. In our case the average senior class in the students course and school was used as this standard. (2) All qualitative terms are avoided since it is impossible to define them so that they call up the same idea in the minds of different judges. Instead, we have used fifths of the group, a concept about which there should be no difference in opinion as to what is meant. (3) The method allows the discrimination to be made as finely as the judge desires and yet permits

FIGURE 1.—SAMPLE RATING BLANK

Will you please rate the student named below for the traits indicated. Place a dot along the line after each trait, grading the student as finely as you care to. Please give the rating independently without consulting others. The record sheet is to be returned to the secretary's office within three days.

JONES, JOHN Instructor—D

Among the members of *the average senior class in this student's course and school* the student would rank in the

	Lowest 5th	Fourth 5th	Middle 5th, Average		Second 5th	Highest 5th
Common sense						
Energy						
Initiative						
Leadership						
Reliability						
General Ability						

the investigator to determine approximately how small divisions in that grading have sufficient reliability to make them worth while. The results on this phase of the problem will be discussed later in the paper. (4) The units of measurement may be readily transmuted into equivalent units of the standard deviation on the basis of the distribution of the judgments. In our blank the measurements may be made in millimeters or any larger portion of the line and changed into units of the standard deviation by Thorndike's table.

Just a word as to the choice of the particular traits for use on the blank. A list of something over 300 traits was first compiled from the studies by Cattell, Wells, Yerkes and LaRue, Davenport's Trait Book, Mann's study of engineers, etc. From this list, 50 were selected and submitted to three different groups to be arranged in order of their importance in recommending graduates for employment. These arrangements were made by the members of the seminar in psychology, the three men in the employment office, and a group of seniors and juniors in the teachers' training courses. The result is shown in Table I.

TABLE I

COMBINED ORDER OF MERIT FOR TRAITS IN RECOMMENDING GRADUATES FOR EMPLOYMENT

	By all (43)	Q.	Extremes	Seminar (6)	Office (3)	Students (14)
common sense	1	6.5	(1-23)	3.0	2.0	1.0
judgment	2	10.5	(1-45)	8.0	3.0	8.0
initiative	3	6.0	(1-39)	2.0	11.0	9.0
reliability	4	9.5	(1-48)	13.0	13.5	4.0
efficiency	5	8.5	(2-38)	7.0	19.0	6.0
intellect	6	9.0	(1-39)	4.0	6.0	11.0
clearness of thought	7	5.5	(2-44)	9.0	23.0	3.0
understanding of men	8	10.0	(1-47)	22.0	7.5	7.0
accuracy	9	10.5	(2-43)	23.0	35.5	2.0
integrity	10	15.5	(1-47)	16.0	4.0	13.5
energy	11	10.5	(4-43)	5.0	5.0	18.0
technical skill	12	15.0	(1-45)	21.0	21.0	10.0
loyal	13	13.0	(1-46)	12.0	1.0	29.0
industry	14	13.0	(4-47)	1.0	9.5	37.0
moral	15	18.0	(1-49)	31.5	13.5	12.0
resourcefulness	16	7.0	(8-42)	17.0	15.5	5.0
foresight	17	10.0	(7-39)	14.0	26.5	21.0
thorough	18	11.0	(4-48)	28.5	34.0	19.0
conscientiousness	19	12.0	(2-48)	10.0	22.0	27.5
leadership	20	14.0	(1-44)	11.0	15.5	30.0
ambition	21	11.5	(2-47)	26.0	28.0	17.0
perseverance	22	13.0	(3-49)	6.0	42.0	25.0
originality	23	11.0	(4-46)	19.0	25.0	24.0
tact	24	12.5	(7-50)	27.0	20.0	23.0
systematic	25	13.5	(5-47)	33.5	44.5	13.5
self-reliant	26	13.5	(4-47)	15.0	12.0	39.0
concentration	27	10.0	(2-44)	28.5	34.0	19.0
broad-minded	28	16.0	(3-50)	24.5	26.5	26.0
co-operativeness	29	11.0	(9-46)	24.5	17.0	36.0
courage	30	15.5	(3-48)	35.5	7.5	33.0
imagination	31	12.5	(5-50)	20.0	18.0	38.0
well-informed	32	8.0	(1-49)	38.5	44.5	19.0
stability	33	16.0	(5-48)	37.0	35.5	27.5
careful	34	12.5	(6-48)	43.5	47.0	16.0
practical	35	8.0	(3-48)	40.0	31.5	34.0
enthusiasm	36	6.5	(6-45)	28.5	9.5	41.0
adaptable	37	5.5	(14-48)	33.5	46.0	35.0
memory	38	11.5	(7-49)	49.0	40.0	21.0
patience	39	8.5	(3-49)	31.5	24.0	40.0
observation	40	9.5	(10-50)	47.0	38.0	30.0
quickness	41	7.5	(4-49)	47.0	37.0	32.0
inquiring	42	8.5	(8-48)	41.0	33.0	44.0
aggressive	43	10.5	(11-50)	45.0	29.5	47.0
firmness	44	8.0	(17-48)	43.5	29.5	46.0
oral expression	45	10.0	(5-50)	48.0	39.0	43.0
presence	46	8.5	(1-50)	38.5	31.5	48.0

TABLE I—*Continued*

apprehension	47	10.0	(4-50)	42.0	48.0	45.0
profound	48	5.5	(6-50)	30.0	50.0	50.0
dignified	49	3.5	(23-50)	50.0	49.0	49.0
ease of learning	50	10.0	(5-50)	35.5	43.0	42.0

CORRELATIONS

	(r from R)
Seminar and employment office	.57
Seminar and students	.54
Employment office and students	.28

Among the traits which were near the top of these lists we then selected five which seemed to represent different important factors in personality from the point of view of employment, and which were not sufficiently indicated by the scholarship records or "General Ability." The latter term allowed the judge to weigh the traits subjectively and to summarize his opinion of the student.

In evaluating the method the first question is, how far may the judgments be relied upon? How sure are we that other capable judges equally acquainted with the individuals would give like estimates? The correlation of series of estimates on the same people seems to offer the best means of answering this question. The data are summarized in Table II, Reliability of Estimates.

TABLE II—RELIABILITY OF ESTIMATES

COLLEGE SENIORS JUDGED BY MEMBERS OF THE FACULTY AT THE CARNEGIE INSTITUTE OF TECHNOLOGY

College	Gen. A.	Com. S.	Init'e	Lead'p	Reliab.	Energy	Av.
College of Applied Science							
Correlation of ranks							
Measured in millimeters							
judgment and 1 other (64 cases)	.53	.54	.53	.64	.30	.67	.54
1 judgment and 1 other (30-36 cases)	.63	.52	.42	.68	.50	.69	.57
2 judgments and 2 others. (30-36 cases)	.76	.62	.67	.77	.71	.78	.72
Measured in fifths							
2 judgments and 2 others.	.69	.60	.67	.77	.64	.73	.68
Product-Moment cor. of transmuted tenths							
2 judgments and 2 others. (30-36 cases)	.76	.52	.64	.79	.71	.70	.69

TABLE II—*Continued*

College	Gen. A.	Com. S.	Init'e	Lead'p	Reliab.	Energy	Av.
M.M. College for Women (24-26 cases)							
2 judgments and 2 others. . . .	.44	.59	.69	.79	.61	.70	.64
Correlation of ranks measured in m.m.							
Product-Moment cor. of transmuted tenths	.44	.62	.68	.80	.69	.62	.64
College of Applied Science (30 cases)							
Correlation of ranks							
2 judgments in fifths and the same 2 in m.m.	.98	.98	.88	.97	.90	.97	.94
2 judgments in fifths and the same 2 in transmuted tenths	.86	.89	.91	.87	.96	.97	.91

All the correlations are between a series of judgments selected at random from those made on each student and similar series selected in the same way from those judgments remaining. The same series of single judgments or of combined judgments on the same students is always used in the correlations compared, but the judgments are scored in different ways.

The first two rows of figures compared with all the others in the table indicate that a single judgment is not sufficiently reliable, but that two judgments combined give approximately a reliability of 0.7 and may be relied upon when no more judgments are practicable. Four judgments combined, which we use, should then give us a reliability of .83, if we apply William Brown's formula for estimating the number of combined judgments necessary to attain a desired degree of reliability.[3] It is interesting to note that, if the correlation between two single series is .55, as here, the correlation between the two series combined and two other series should theoretically be .71. This agrees with our empirical findings.

In the Margaret Morrison Carnegie School it is possible to check the order of merit for the seniors which has been obtained by combining the estimates of various instructors, none of whom judged the whole class, by two orders of merit

[3] The Essentials of Mental Measurements, note, p. 101.

for the whole class furnished by the dean and by the secretary of the school who has charge of employment. The orders of merit arranged by each of these administrative officers correlates over .70 with the combined order of merit of the faculty judgments on the "general ability" of various parts of the class, taken from the estimate blanks. The combined order of merit of the administrative officers agrees with the result of the same combined faculty estimate with a correlation of .75. All correlation coefficients for rank orders in Table II are obtained by Pearson's method for calculating P and translating to *r*.

Important data as to the form of scoring these estimates are also provided in Table II. Notice the three rows of coefficients in the second division of the table. The averages are .72, .68 and .69. They suggest that refinements of measurement make very little difference in the reliability of an order of merit obtained from two judgments chosen at random. This is true at least so far as the orders of merit of these thirty seniors in the engineering college were concerned. The results are corroborated by the next two rows of data on the seniors in the college for women, which show the same average, .64. Since four judgments are averaged the students were fairly well discriminated in rank.

The last division of the table, moreover, shows that an order of merit obtained from two judgments combined remains practically the same whether the judgments are scored one way or another. Measurements in fifths give about the same order of merit as those in millimeters or transmtued tenths. The correlations are over .90. If an order of merit is all that is desired, records in less than fifths or the use of transmuted measures are probably unnecessary refinements. When the methods differ as to particular students, however, the refined method may be safer. With our blank the position of the dot can be read directly in tenths as easily as in fifths.

There is some tendency for students in certain divisions to be ranked higher than in others. This may raise the correlations. If present, however, the spurious correlation does not affect our conclusions. In the women's college the order of merit agreed well with that of the two administration officers who ranked the entire class. At least two judgments are necessary for reasonable reliability, and the measurement of combined judgments need not be in smaller units than fifths if conclusions are limited to the group as a whole, rather than directed to particular students.

TABLE III

INTERCORRELATIONS OF ABILITIES

Thirty seniors in the College of Applied Science estimated by four judges in tenths of an average graduating class and the scores then transmuted into units of the standard deviation. Scholarship rated by the total scholarship in credit hours transmuted into units of the standard deviation. The correlations were calculated by the product-moment formula.

	Schol'p.	Gen'l. A.	Com. S.	Energy	Init've.	Lead'p.	Reliab.
Scholarship	...	.73	.58	.73	.62	.39	.72
General ability	.73	...	.85	.74	.78	.71	.84
Common sense	.58	.85	...	.68	.76	.68	.78
Energy	.73	.74	.68	...	.78	.46	.76
Initiative	.62	.78	.76	.78	...	.75	.80
Leadership	.39	.71	.68	.46	.75	...	.55
Reliability	.72	.84	.78	.76	.80	.55	...
Average	.62	.78	.72	.69	.75	.59	.74

If the reader will now turn to Table III, the intercorrelations may give us some other hints in evaluating this particular rating card. Which of these specific traits gives the most unique information not afforded by the grades in scholarship? To answer this question we may note which trait shows the lowest correlation with scholarship. With this group of seniors in the engineering college the estimate of "leadership" is least indicated by scholarship. We also note that "general ability" shows the highest intercorrelations with these specific traits, even when we disregard the intercorrelations with scholarship. For a single term "general ability" would, therefore, probably give us the most additional information about the whole group of specific traits. If the problem justified the labor of the calculations this conclusion could be checked by the partial intercorrelation of each of the traits with the others independent of their relations to scholarship.

When considering a particular person, what sort of numerical rating will be most usable? This is largely a question of practical convenience. The method we use is to record the average rating of the faculty judges in a particular trait, then to arrange these in ten equal groups. By this method the rating of the student is in the *actual* tenth of his class in which he fell on the average for that trait. This is, of course, different from the average estimated tenth. For example, the separate judgments of the seniors in the engineering college

distributed in the various estimated tenths in general ability as follows, beginning with the estimated lowest tenth and stated in percentages: 2, 3, 8, 3, 9, 29, 17, 8, 15, 6. We may note in passing that the transmuted value in terms of the standard deviations for an estimate in each of these tenths for this college was as follows, omitting decimal points: —24, —18, —14, —11, —8, —3, +3, +7, +11, +20.

In spite of the fact that there is a tendency to place more than a tenth in the middle and upper estimated tenths, the discrimination is probably better than with other methods of estimation. For example, the distribution of the grades in scholarship of the same class under the six marks used showed the following percentages of credit hours for each mark: 1, 7, 15, 54, 19, 4.

A more precise quantitative score also seems advisable, at least for general ability. For this purpose we have used estimated tenths transmuted into terms of the standard deviation. With this quantitative score a unit means approximately the same at one position on the scale as at another. This is not true of decile units or ranks in an order of merit, in which adjacent extreme tenths theoretically differ from each other about three times as much as those tenths near the middle.

The office should also be informed as to the variability of these ratings. For example, with the estimates of general ability of the 64 engineering seniors, we can say that the chances are roughly 9 out of 10 that a student would not be estimated more than 2 tenths of an average class differently, even in the most variable tenths, by a similar average judgment of four members of the faculty.

W. D. Scott has suggested a method by which the rating blank can be made more concrete if comparison can be made to a known group which is stable enough so that typical individuals may be selected for a standard scale. For example, when the divisions are in fifths, at the boundaries of the divisions may be inserted the names of those persons in the standard group who are highest, lowest, middle, etc. The estimator would then judge an individual to be between Mr. A. and Mr. B., or between Mr. B. and Mr. C., etc. In this form the method is being tried out by the Bureau of Salesmanship Research.

The complete answer as to whether it is worth while to supplement the scholarship ratings of college students by such estimates of ability as have been attempted here will be possible only after we can determine whether they assist in making a more accurate prediction of success in life. This

must wait until we have data upon these graduates some years after they have left the schools.

That these estimates give illuminating information about certain students cannot be doubted, however, when one finds such records as those of Mr. A. and Mr. B. given in Table IV. Without such estimates of traits, an institution has no systematic record in available form of anything except scholarship. That would certainly be an inadequate basis for judging these individuals. On the other hand it must be recognized that for the great majority of the seniors the estimates and the scholarship records are quite similar. The record of Mr. C. may be said to be fairly typical and that of Mr. D. is the other extreme.

TABLE IV

RECORDS OF INDIVIDUALS

Seniors	Mr. A.	Mr. B.	Mr. C.	Mr. D.
Standard deviation:				
Scholarship	−.24	+.18	+.26	+.82
General ability	+.36	−.30	+.30	+1.40
Actual tenths of the class:				
Scholarship	3	7	7	10
General ability	6	4	6	10
Common sense	8	1	4	10
Energy	8	6	6	10
Initiative	8	4	4	9
Leadership	10	3	7	8
Reliability	7	7	6	10

We may recapitulate the experience of the Carnegie Institute of Technology in regard to the method described above when applied to its seniors in 1916. The empirical test of the method under the conditions found in its four colleges shows: 1. The plan of estimating traits within fifths of an average class in the student's course in college by placing a dot on a line, is so easy to use that replies can be secured, without serious annoyance, from teachers who do not have to estimate more than about a dozen students for six traits. 2. The average of four estimates on each student was found to give fairly constant orders of merit when such estimates on personal traits were made by those as well acquainted with the individuals as instructors in laboratory courses with small groups. An estimate by one member of the faculty is unreliable. 3. The method allows for a quantitative estimate on a common standard without requiring all the members of the class to be known by the same person. 4. The records supplement the scholarship ratings of some students in a most suggestive way. 5. Five traits selected because of their esti-

mated high importance in recommending graduates for employment, were common sense, energy, initiative, leadership and reliability. Among these leadership was least correlated with scholarship ratings. Estimates of general ability showed the highest intercorrelations with the special traits. 6. Scoring the estimates in divisions less than estimated fifths of the class or in transmuted measures did not give notably different orders of merit.

ALTERNATIVE METHODS FOR MENTAL EXAMINERS

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Various types of investigations, particularly those concerned with practise, memory and transfer, demand the use of much alternative material of a homogeneous character. In the type of mental examination represented by the intelligence scales this need has also made itself felt, as a precaution against the vitiation of results through the subject's fore-knowledge, incidental or purposeful, of the test material. In accordance with this situation have been compiled the tables of alternative material to be described. Those dealing with number material include addition, subtraction, multiplication and division, consecutive magnitudes, the reversed clock test, the problem of the enclosed boxes, the "ingenuity" test, a "relational" test with numbers, and memory for digits. Others dealing with language material comprise tables for alphabetical sequence, alternate directions material and vocabulary lists, together with a "cued combination" method for vocabulary and spelling. A simplified form of the Kent-Rosanoff frequency tables in the association test is also included.

As publication of the tables is not now possible, the writer will gladly answer inquiries in regard to experimental material from them. Here is described the present content of the tables, but it is not unlikely that they will be extended to other sorts of experimental material, and suggestions in this regard will be most welcome.

TABLE I. ADDITION-SUBTRACTION

Random drawings of the two place numbers from 11 to 99 inclusive, are grouped in series of 10 numbers each, with no number occurring more than once in each series, and in vertical column, thus:

34
79
87
68
25
82
27
30
24
23

Fifty such series have been prepared. They may be used either for adding the columns, or for adding (or substracting) a fixed amount from each number (Woodworth-Wells constant increment test).

TABLE II. ADDITION-SUBTRACTION

A series of 100 random pairs of six place numbers was prepared. Each pair is given together with its sum. Any pair may be presented as an addition test, in which case the sum checks the correctness of the subject's answer. As a subtraction test, the sum is used as the subtrahend, and either number as the minuend. The other number checks the correctness of the subject's answer. Examples:

1.	683936	859629	1543565
2.	791661	554668	1346329

The table thus provides 100 such examples in addition, and 200 in subtraction.

TABLE III. MULTIPLICATION-DIVISION

A series of 200 random pairs of three place numbers was prepared, in which no digit occurs more than once in the same number. Each pair is given together with its product (after Crelle's tables). If any pair is presented for multiplication, the product checks the correctness of the subject's response. For division, this product is presented to be divided by either of the pair, and the other number checks the correctness of the quotient obtained by the subject. Examples:

1.	384	194	74496
2.	761	257	195577

If, in division, a remainder is desired, its amount is added to the dividend before presenting the problem. The table provides 200 such examples in multiplication and 400 in division.

These tables presenting mathematical problems in the abstract, are of course equally adaptable to any concrete setting in which the examiner may think fit to give them.

TABLE IV. CONSECUTIVE MAGNITUDES

A series of 1,000 four and five place numbers is presented. The nature of this list safeguards it against duplication except from clerical error. The subject may arrange a small group of the numbers in order of magnitude. The table begins,

8846
8059
10604
10653
10097

TABLE V. REVERSED CLOCK. (BINET ET AL.)

The problem is to tell the time indicated if the hands are reversed from that of a given time on the clock. 132 such problems are gathered in 11 columns of 12 each. It is intended that the problems of one experiment shall not be chosen from outside a single column of twelve. The list begins with the times, 3.36, 8.13, 12.41, 10.19.

As both original and reversed times are given in the table, the problem may be given from either one, and the answer checked from the other.

TABLE VI. ENCLOSED BOXES. (TERMAN, YERKES)

There are given twelve additional problems, based on combinations of 1-4 boxes.

TABLE VII. "INGENUITY." (TERMAN, YERKES)

The principle of the problem is preserved, but its statement altered to the following:

A doctor must measure out exactly (q) ounces of medicine for a man who is sick in the woods. He has only an (m) ounce measure and an (n) ounce measure to do it with. Show how he can use these measures to get just the right dose of (q) ounces without any guessing. He pours from one measure to the other, and what he does not want he pours back into his medicine bottle.

In the table, the problems are stated by giving first the smaller measure, then the larger measure, and then the amount to be obtained. Thus, 3-5-7 signifies, "3 and 5 to get 7." This problem, the first of those given by Terman and Yerkes, takes five steps for its complete solution. Their second problem, 5-7-8, takes seven steps. By varying these quantities, alternative problems have been prepared, classed as *a* when the larger measure is filled first, and as *b* when the smaller measure is filled first. The number of these alternates for differing degrees of complexity is as follows:

No. steps in solution	3	5	7	9	11	13	15
a—problems	17	18	13	11	7	3	1
b—problems	1	13	14	11	7	3	1

Also one each of 9, 11, 13 and 15 step problems in which either measure is filled first.

The problems may be arranged in series of increasing complexity, care being used that the solution of a shorter problem is not involved in the solution of a longer one. A table of thirty such series is prepared, one of which is:

No. steps	3	5	7	9	11	13	15
Problem	7-8-1	7-9-11a	4-5-7b	5-8-12b	4-9-11b	8-9-5b	8-9-4a

In three step problems, the direction to fill a certain measure first may be dispensed with.

TABLE VIIIa. MATHEMATICAL RELATIONS. (AFTER YERKES' MULTIPLE CHOICE AND RELATIONAL TESTS)

Tables are prepared adapted to two forms of this test. First, the subject is required to *state* a certain relationship which is thus presented:

What must be done to each of these numbers,	To get these numbers,
289	292
378	381
276	279

The nature and complexity of the relations to be presented is indefinitely variable, and must be decided by the examiner. To facilitate the construction of such test material, the following tables are prepared:

100 random 3-place numbers between 200 and 450
15 2-place and 15 3-place numbers which are multiples of 3
15 2-place and 15 3-place numbers which are multiples of 4
15 2-place and 15 3-place numbers which are multiples of 6
10 2-place and 15 3-place numbers which are multiples of 7
10 2-place and 15 3-place numbers which are multiples of 8
10 2-place and 15 3-place numbers which are multiples of 9
Three examples in 2-place and three examples in 3-place figures of each of the relationships: multiplication and division by 3, 4, 6, 7, 8, 9.
Three examples in 2-place figures of each of the relationships: 2/3, 3/2; 3/4, 4/3; 5/6, 6/5; 6/7, 7/6; 7/8, 8/7; 8/9, 9/8.

TABLE VIIIb

Second, the subject may be requested to *apply* the relation, with or without its statement. Then a blank is left in a series presented where he is to insert the proper figure. Thus:

232 235 238 241 .....

The tables quoted under VIIIa are also adapted to this form of experiment.

TABLE IX. MEMORY FOR DIGITS

108 orders of the nine digits are prepared according to these rules: (1) No order to have a figure differing from the preceding figure by 2, 1 or minus 1. (2) No order to have the same difference occurring twice in succession, as 2,5,8; or 9,5,1. (3) In the same group of three orders, no successive orders to have the same figure in the same position. (4)

In the same group of three orders, no two orders to begin or end with the same figures.

For convenience, the digits in each order are divided into groups of three. Thus the first group of this table is, (read horizontally),

286	153	947
749	625	183
851	742	639

This table is equally adapted to the "reversed" repetition of digits (Bobertag, Terman), except that then, differences of plus 2 between successive digits will be involved.

If the conditions are not suitable for the usual type of memory test, a partial substitute (after W. D. Scott) may be had in requiring the subject to transcribe portions of this table, printed at one end of the test form, at the other end, thus,

286153947	.....
749625183	.....
851742639	.....

But in this form of test the rôle of memory is practically absorbed by attention.

Table X. Alphabetical Sequence

A list of 1,000 names in random alphabetical sequence is prepared. The constitution of this list does not wholly safeguard it from duplications, but they are practically eliminated. Among the many uses to which such a list may be put, is the arrangement of a small portion of the list in alphabetical order; or better, if responses are written, the indication of this order by prefixing to the names the numbers 1, 2, 3, etc. The table begins,

Foley, Annie E.
Gates, Mary M.
Kennedy, Allan G.
McDonald, Alice D.
Robertson, Clara L.

Table XI. Directions

The text of the Woodworth-Wells *hard directions* test is so varied as to alter each of the responses called for. The number of alternative responses thus provided varies from 10 to 25 among the 15 directions of the test. The order of their presentation is also varied. In preparing a test form, the choice of each direction, and its place of sequence in the form, is governed by chance, giving an indefinite variety of test forms from the same foundation. Two sample forms are,

Put the number 736 before this name of a boy .....John. ⁂Write any letter except *g* just after this comma,..... ⁂If people believe Lincoln was president in the Civil War, cross out what you last wrote; but if it was someone else, put in the number to complete this sentence, "A dog has.....feet." ⁂Notice the numbers 2, 9. If iron is heavier than water, write the larger number here.....; but if iron is lighter, write the smaller number here....., ⁂Write *no*, no matter whether California is in Asia or not..... ⁂Write again what you last wrote, here..... ⁂Write the first letter of your first name and the second letter of your last name at the beginning of the dotted line..... ⁂Write *yes* if 3 x 3 are 10.....; if not, make a cross here..... ⁂Make a figure 3 under any one of these letters F G H I J. ⁂If coal is black, make a figure 8 here.....; but if not, tell where the sun sets..... ⁂Make a dash after the longest of these three words, sand cow cattle . ⁂If Thursday comes after Wednesday, make a square here.....; but if not, make a circle here..... or two crosses here..... ⁂Give a wrong answer to this question, "How many days are there in the year?"..... ⁂Show by an exclamation point when the days are longer: In summer?..... In winter?..... ⁂Give the correct answer, *yes* or *no* to this question, "Do turtles have shells?" .....

If a square is round, make a figure 3 here.....; but if not, tell where the sun sets..... ⁂Write *no* if 3 x 3 are 9.....; if not, make a cross here..... ⁂Write again what you last wrote, here..... ⁂Show by a circle when the nights are shorter: In summer?..... In winter? ..... ⁂Write any letter except *e* just after this comma,..... ⁂Write *yes*, no matter whether Egypt is in Africa or not..... ⁂Make a comma after the shortest of these three words, pocket pole gun ⁂Give the right answer to this question, "How many months are there in a year?"..... ⁂If you believe Paris is in Asia, cross out what you last wrote, but if it is somewhere else, put in the number to complete this sentence, "A chicken has.....legs." ⁂Notice the numbers 6, 9. If iron is lighter than water write the smaller number here.....; but if iron is heavier, write the larger number here..... ⁂Make a dot to the right of any one of these letters F G H I J ⁂Put the number 681 between these names of boys, John Alfred ⁂If Wednesday comes after Tuesday, make a circle here.....; but if not, make a square here.....or two crosses here..... ⁂Give the correct answer, *yes* or *no*, to this question, "Are tigers fierce animals? ..... ⁂Write the first letter of your first name and the second letter of your last name at the end of the dotted line.....

TABLE XII. VOCABULARY. (AFTER TERMAN, THE MEASUREMENT OF INTELLIGENCE, 1916, pp. 224-231)

Two thousand words not in Terman's standard list of 100 are similarly selected, at random according to their positions in *Webster's Primary Dictionary*. Random drawings from these 2,000 are grouped in 20 series of 100 words each. The words in each series are presented roughly in order of their difficulty, beginning with the easiest.

TABLE XIII. THE METHOD OF CUED COMBINATION

Its purpose is (1) to make the Vocabulary test of Table XII practicable as a group experiment, (2) to serve also as

a test of spelling without the examiner's pronouncing the word to be spelled.

In tests of word-combination, the word to be combined is usually left an entire blank. Here the word is not left wholly blank, but a determining cue is given. The extent of this cue should be such that (1) if the word forms a part of the subject's effective vocabulary, he can hardly fail to combine it properly; (2) if he does not know the word, he cannot supply it by guessing. This cueing must be done carefully, and its extent depends somewhat on whether the test is meant primarily for vocabulary or for spelling. In the latter case, only those portions of the word need be omitted where errors in spelling are most apt to occur.

In representing omitted portions of the word, it is sometimes desirable to represent the number of letters omitted, and sometimes not so. In the former case, each letter omitted is represented by a period, thus:

The boy was sucking a big ripe or. . . e

In the latter case, the omitted portion, of whatever length, is represented by a dash, as is usual in combination tests:

A cent is made of co————

Similar brief sentences, with appropriate cues for the word to be supplied in each, are prepared for

(1) The 100 words of Terman's Vocabulary Test. The same methods is now being extended to the 2,000 alternative words of Table XII.

(2) The "100 commonly misspelled words" of Hammond and Herzberg's "Style-Book of Business English," 1916, pp. 113-4. These are cued especially for spelling. Such methods of spelling test relieve the examiner from speaking the words, and the test from errors traceable to this cause. The subject simply fills out the test-form given him. One at the same time tests the ability to use the word correctly, as in testing for vocabulary.

(3) For spelling alone, a mixture of misspelled and correctly spelled words is efficient.[1] Such misspellings as are given by Hammond and Herzberg are listed with other correctly spelled words selected from Table XII. The subject *corrects* the misspellings he notes.

[1] Cf. Kemble, Standard Tests for Employees, 1916.

TABLE XIV. FREQUENCY TABLES FOR FREE ASSOCIATION. (ABRIDGED FROM KENT AND ROSANOFF)

Since the "median of community"[2] in associative response is not affected by the responses of less frequency than 1%, the original tables of Kent and Rosanoff are reduced to a small fraction of their bulk by eliminating these, and the process of evaluation is also simplified. For the stimulus-word *Dark* the 114 items of the original Kent-Rosanoff table become 7, as follows:

Dark
76 black
15 bright
28 color
11 gloomy
427 light
221 night
22 room

The precision of the method is unaffected.

TABLE XV. TOWNS AND STATES

A list of 400 leading towns and cities of the United States is prepared, containing the two largest towns in each State, and other towns over 15,000 population (together with Lakewood, N. J., and Portsmouth, N. H.), according to census of 1910. The towns included in this list are presented in random order. Any selection of these, preferably not less than 30, is given to the subject, who indicates the State in which the town is situated. When a town is specified for more than one State, (e. g. Jackson), the States specified for it in the table are to be named; (e. g. Mich., Miss., Tenn.). Credit is not given for States not specified in this table, though they may contain a smaller town of the name called for, (e. g. Jackson, N. H.). The table begins,

Muskegon, Mich.
Ansonia, Conn.
Walla Walla, Wash.
Hagerstown, Md.
Leominster, Mass.

This table may be combined with Table X for a convenient associative memory method. Names taken from Table X are attached at random to addresses from the present table, and thus presented to the subject. After a given interval, it is seen if the subject, on being given the names alone, can recollect the address belonging to each.

[2] Wells, The Question of Association Types. *Psychol. Rev.* 1912. 19, 259.

TABLE XVI. LETTER-SQUARE

This table consists of 375 random drawings of one of twenty letters, paired with a random drawing of one of ten numbers, thus B 3, Q 8, T 5. There is presented to the subject a figure with 200 squares, designated vertically by letters and horizontally by numbers. The subject (1) gives the letter and number corresponding to five designated squares, (2) marks in a specified way five other squares whose letter and number are given. The table designates combinations of letter and number to be employed. No letter occurs more than once in any line of 15 combinations. In each line of 15, no number occurs more than once in the first 5 combinations or in the second 10 combinations.

A sample test form is,

	A	B	C	D	E	F	G	H	J	K	L	M	N	P	Q	R	S	T	U	W
1																				
2																				
3		x																		
4																				
5		c																		
6	n																			
7				g																
8																				
9															t					
10																		f		

6. Each of the squares in the diagram above is named according to the letter under which it stands and the number on the same line with it. Thus the square with an x in it is named B3.

Give the letter and number to name the squares which have in them the small letters c.....; f.....; t.....; g.....; n.....

Put a figure 6 in square W2.
Put a figure 8 in square N4.
Put a figure 2 in square F3.
Put a figure 7 in square G4.
Put a figure 4 in square J7.

Printed forms have been standardized for this experimental material. Each piece of test material, with its written instructions, is not more than 3 inches in height. The width is 7½ inches, or half or quarter thereof, according to space required. Test-forms from the different tables occupy the following portions of a type page 7½ x 9":

Table I, Addition-Subtraction,	1/12
Table II, Addition-Subtraction,	1/12
Table III, Multiplication-Division,	1/6

Table IV, Consecutive Numbers,	1/12
Table V, Reversed Clock,	1/6
Table VII, Ingenuity,	1/3
Table VIII*a* or *b*, Mathematical Relations,	1/6
Table IX, Memory for Digits, (Transcription),	1/6
Table X, Alphabetical Names,	1/6
Table XI, Directions,	2/3
Table XIII*a*, Cued Combination, (1)	2/3
Table XIII*b*, Cued Combination, (2)	1/3
Table XV, Towns and States, (3)	1/3
Table XVI, Letter-Square,	1/3

Complete test-forms from Tables I-X, also XV, may be presented, recorded and filed on the standard 5 x 3 card; with the remaining tables, results alone are so filable. Slips of fairly heavy paper cut to 5 x 3 size are more convenient in use than cards, and occupy less space when filed.

Forms like those described are conveniently left blank except for the instructions to the subject, and any variation of the test-material entered upon it, from the tables, in printing, multigraph, typewriting or manuscript. The content of the tests is thus changed whenever desired. For individual examinations it is, in most of the tests, efficient to have the instructions (when not verbal) typewritten on a 5 x 3 slip *a*, and the test material on a second slip *b*. A third slip *c* is then clipped adjacent to the experimental material on slip *b* and on the slip *c* the subject records his response. This slip is then filed as his record in the test, while the slips *a* and *b* are available for repeated similar use. This is most convenient in practice and transfer experiments. Where a number of tests are made in this way with a single subject, the record slips may be filed upon larger master-cards (standard sizes up to 14¾ x 9½) or one behind the other in the regular 5 x 3 cabinet, suitably indexed.

(1) Words 38-70 inclusive, of Terman or alternate Vocabulary Lists.

(2) Seventeen random selections from Hammond and Herzberg's List.

(3) Different composition for 5 x 3 filing.

PSYCHOLOGY AS APPLIED TO THE NATURAL SCIENCES

By A. A. Roback, Harvard University.

Ever since positivism has taken a hold on science, there has been a tendency to apply the method employed by the natural sciences to all the sciences, so much so that in some quarters hope is even held out for such an application in the domain of ethics.[1] Owing to this circumstance, one finds it necessary to outline the scope of the term "natural sciences."

It may be stated then, at the outset that the term "natural sciences" as employed in this article is to embrace not only the biological and geological sciences with all their various subdivisions but also, and in fact more particularly so, the physical and exact sciences. In other words, the designation is used broadly enough to include every science depending, for the most part, upon the observation and recording of natural phenomena as well as the mathematical basis underlying their interpretation, while on the other hand, it is sufficiently restricted to exclude the sociological and historical disciplines which should be treated under a different heading. Psychology, in its experimental phase, especially as treated by the behaviourists and allied schools may well come under this rubric; but the very fact that the status of this science is under discussion is sufficient warrant for confining ourselves at present to the various branches of the *Naturwissenschaften* including physics, astronomy, chemistry, geology, mineralogy, and the biological sciences, such as physiology, botany, zoölogy, anatomy, and their various subdivisions. This, however, by no means goes to say that applied psychology, in its present stage, has anything to offer to all the sciences mentioned. But at least the direction may be shown in which any improvement may be expected, and in general, a grouping of the different sciences is convenient, since the principle involved in one of the members of the group is likely to prove fundamental in all. The question before us then, is: In what way can psychology be of service to science in dealing with the observation of natural phenomena?

[1] The reference here is notably to the movement inaugurated by L. Lévy-Bruhl and Georg Simmel.

It will be noticed that in all other fields, such as law, medicine, pedagogy, etc., applied psychology has both a *negative* and a *positive* contribution to make. It not only points out the obstacles in healing, but it actually offers its services to effect a cure. It not only exposes the flaws in the legal system of to-day, but sets about devising means by which the cause of justice might be furthered, aside from those flaws. In art, we are not only told what to be on our guard against, but we are taught how definitely to enhance the enjoyment of an artistic production. In short, psychology has incorporated itself in the particular pursuit that summoned it. The salesman is making more sales and the physician cures more effectively by dint of their psychological principles. You can not really separate the two while the selling or curing is in operation.

The relation, however, is not so intimate between psychology and science, especially the natural sciences. Here the psychologist does not pretend to lead the naturalist in his investigations, but merely to act as a check. He cannot hope to make the physicist or the astronomer perceive the better, or the quicker or the more, but reminds him only that he must make allowance for certain facts in matters where the minutest detail may make a vast difference as to results. Hence, the conclusion that applied psychology has only a negative value and not a positive, for natural science.

The reason for this deviation of applied psychology from its usual course is obvious. All other departments of human endeavor, to which psychology can be applied, have a *practical* bearing, and their end is utility. Even art aims at enjoyment. Science, however, although eventuating in utility, may yet be taken up for its own sake. It may be true that every discovery is an invention *in potentia*. Yet science would still retain its value even were the discovery the end of the matter. The search after and attainment of a truth per se has a distinct value apart from the exploitation of it in the economic world. We may reach *this* conclusion then that psychotechnics depends as to extent of applicability upon the degree of practical bearing of the department to which it is applied.

There is another reason for this apparent thinness of applied psychology in our field. In all the other subjects there are two phases to the reaction, both falling into the sphere of human activity and human interests. In law it is the court officials trying to bring about a certain state of affairs by means of influence brought to bear on the jury or the accused. In business, the salesman cannot rest content with picking up certain *impressions,* but must give vent to

certain expressions in order to persuade his prospective customer to make the purchase. The artist, if he is to be successful, must consciously or unconsciously take into consideration principles that operate, or will, in the long run, operate on the mind of man. He may not create anything with a view to pleasing *others,* but surely he must please himself, and in that event, he is really the prototype of the future cultivated public. We have here a purposive or intentional relation.

Now this motor element which presupposes another human being to complete the relation is entirely missing in the natural sciences. But it is precisely this human objective which is missing that gives rise to the positive part of psychotechnics. It is just because the naturalist does *not* make his will felt, does *not* enter into a life-attitude with another personality that there can be no prognostication of a psychological nature.

It is not therefore the fault of applied psychology if it has not the double importance for the natural sciences that it has in medicine or jurisprudence and so on. It is rather to be attributed to the nature of the case, i. e., to the conditions of science in general. On the other hand, however, these conditions must not be regarded as limitations in any way. As a matter of fact, the reverse seems to be true. The exactness of the physical sciences and the growing positivism of the biological sciences are in a large measure due to the lack of the human objective which, if present, would entail variability. Instead, the naturalist enjoys the privilege of studying conditions that are stable, and this fixity of conditions, although it precludes the life-attitude of one personality towards the other, possesses the excellence that we are, at least, *certain* of the results, once results have been obtained—a circumstance that has conduced to the preëminence of the physical sciences.

But there is again the danger of overrating the infallibility of scientific results because of the infallibility of science. That science, as a description of the laws of nature, based on the principle of uniformity does not err is a view that scarcely admits of any doubt; but it is, as a rule, forgotten by the zealots of science that the results of any investigation do not fall ready-made from heaven. They must be attained by men, men of *science,* it is true, but men all the same, and *all* men are fallible.

It has been thought that an observation in the physical world is infinitely more reliable than a psychological observation; and these devotees have failed to recognize that there is no strictly *physical* observation, that every result in physics or

chemistry is a psychological process in operation between the subject and object. Far, then, from hoisting up the physical sciences beyond the reach of psychology, we must rather begin with psychology as the starting-point, for *it* is the foundation of all science.

Science, after all, we must remember, is the construction of the scientist. It is artificial since it never brings us into touch with ultimate reality. In the words of Poincaré, *Gorgian* as it may sound, "Not only science cannot teach us the nature of things; but *nothing* is capable of teaching it to us, and if any god knew it, he could not find words to express it,"[2] and Poincaré is by no means an anti-intellectualist. It is pretty well agreed that the objective validity of science consists not in its presenting an exact model of reality so much as in establishing a certain coherence in the world, or as Poincaré puts it, "It consists in relations that are, will become, or will remain common to all thinking beings." It is at this point that psychology picks up the thread and points out that certain relations are not common to all, and now the question is: what constitutes the difference?

We are constantly reminded that reference must be had to the *facts,* as if the facts were reality as it *is,* ultimately and absolutely, and as if these facts did not involve an element of perception and many other factors that come from within, and consequently are not exactly alike for every individual. It is the business of psychology, then, to answer how universal accord could be brought about by the elimination of these disturbing differences; in other words, how we could obviate *not illusions,* but our ignorance of the illusions.

"But is not illusion real?" seems to be the gist of a vigorous attempt by Prof. Holt[3] to bring to life again a by-gone doctrine decked in a new garb. Of course there lurks an ambiguity in the contention that illusion is real. That a process has taken place which we, after reflection and comparison, call illusion is something incontrovertible. The disputed point is whether the perception experienced by the observer is apt to fit into a system of relations with perfect congruity. It is the lack of this congruity that determines the illusion. "But does the camera ever lie?" asks the realist triumphantly. This question again is fraught with equivocation. The camera is not active in deceiving us, but we are *deceived* just the same on our own account just as if we might have been deceived by looking at an object with the naked eye. It is not the camera that deceives us, but our senses brought into a certain

[2] Poincaré: "Value of Science," p. 138.
[3] The New Realism, p. 303ff.

relation with the camera and the object. A thousand different cameras may give a thousand different impressions, and then we should be obliged to regard each individual impression as a real impression or percept. And if several physicists or astronomers obtained each a different result in their observations, shall we say that all their observations are real?

The underlying fallacy appears to be, as was already alluded to, the total neglect of the psychological factors. The act of perception is likened to the impression on the camera, as if the lenses in the camera or the mirrors were things grown on the field and not fashioned by man to suit his own retino-cerebral apparatus. It is not realized that when the camera gives us a distorted image of anything, it is not the instrument that is doing the work. It is still we who are using our eyes while the camera acts as a sort of transmitter.

I have gone into this general discussion at such great length because it seems to me that the psychical functions have too frequently been disregarded in the interpretation of phenomena, although the truth of the matter is that the physical is nothing knowable without the instrumentality of the psychical; and since trained observers do occasionally have different data it is clear that we must look to psychology for an authoritative statement, as the difference could not possibly be due to deviations in the objects observed, for that would be precluded by the principle of Uniformity of Nature or Conformity to Law.

Now how can the individual natural sciences learn about their dependence on psychology? To begin with the science that forms the basis of all the physical sciences, mathematics, it might seem as if this is entirely independent of psychology, and in a sense it is true inasmuch as the foundations of mathematics are the same for everybody and as mathematical propositions are to be traced back to the principle of identity.

But in mathematics too there are various theories and doctrines, and some of them at least, involve other principles besides that of identity. As early as 1892, when the term applied psychology, except in connection with pedagogy, would probably have sounded almost as absurd as talking of applied metaphysics, J. McKeen Cattell asserted the rights of psychology in the most authoritative domain of science when he declared at the first meeting of the American Psychological Association that "The assumption made by the mathematicians, that an error is composed of a very large number of comparatively small and independent errors, cannot be admitted by the psychologist. . . . The deductions of Laplace and Gauss are of the greatest importance, but it should

not be forgotten that the laws of nature cannot be invented, they must be discovered. It is within the province of psychology to supply physics with the formulae it requires for eliminating errors of observations in special cases."[4]

More recently the Gaussian theory of error has been subjected to further criticism by one of the leading spirits in the new movement of psychology. "To the most elementary presuppositions of the Gaussian Theory of Error" says Marbe in the *Fortschritte der Psychologie*, "belongs the assumption that the variable errors in question have equal probability. The facts show that these assumptions are invalid and the representative of the exact natural sciences and the psychologist would therefore have to be persuaded to trace the errors resulting from psychological principles and eliminate them."[5] Marbe is here referring to the experiments he has undertaken and successfully carried through to establish what he calls the principle of "the uniformity of psychical occurrence." Marbe in his experiments placed several cards before a number of people and asked them each to pick one card out of the few and record it. The results tended towards an astonishing unanimity. When asked to pick out and write down a certain color, most noted down the color red. In the same way if you ask a number of subjects to write down a number between 1 and 10, between 11 and 20, between 21 and 30, 31 and 40, and 41 and 50, the chances are that 5 or the multiple of 5 would be the number chosen, and next come the numbers nearest to 5; the farther away the less preference. These results evince the fact that there is another phase to the problem of probability that mathematicians have not dreamt of. The *a priori* method cannot be applied as long as the probability depends on an agent. To rely entirely upon such a method would be making the reckoning without the host; and it only shows the sagacity of Hume to have included even mathematics under his programme of humanism.[6]

It remained, however, for astronomy to first recognize the significance of psychology for the observatory. Ever since the assistant of the astronomer Maskelyne was dismissed in 1795 for recording stellar transits half a second or so too late, the phrase "personal equation" has come into vogue, and the relations between psychology and astronomy are becoming all the closer as more light is thrown on the subject by further investigation both on the part of astronomers and on the part of psychologists.

[4] *American Journal of Psychology*, vol. v, 1892-3, pp. 286-287.
[5] Fortschritte der Psychologie, vol. I, 1913, p. 60.
[6] A Treatise of Human Nature, Part III, § 1.

The bearing of psychology on the physical sciences is well brought out by Newcombe in the *Astrophysical Journal*.[7] "A mind," he says, "accustomed to dealing with objects the correct perception of which depends mainly on visual inference, is naturally prone to extend that inference to cases where the conclusion would be illusory. Having this in mind we see that observers trained in different ways may depict the same object very differently."

As an illustration of these words, Newcombe gives the results of experiments conducted by himself to show that the astronomer Lowell of the Lowell Observatory had wrongly interpreted the width of the Martian Canals and had read into his observations things that were not actually there.

The experiment of Newcombe's consisted in observing at a distance of 10 meters a number of lines through transmitted light, 7 mm thick and 30 cm long. The lines were ruled on white fine paper and one of them was continuous while the others were broken at regular intervals by spaces 1 cm and more in length. The results of the observation are noteworthy. At the distance of 10 meters, all the lines seemed to be continuous and uniform. As the distance was diminished the perception of the gaps did not come on suddenly, but by gradual steps. What was judged to be a continuous line up and down the paper was really a short line with a faint shade below it, and what was still more surprising, a paper that was known to have no visible lines upon it when placed in the window showed a system of continuous lines similar to those that had been observed before.

What the cause of this illusion is does not actually concern us here, but its value for the interpretation of astronomical observations is tremendous. Newcombe's experiments led him to conclude that the breadth of the Martian Canals which was thought to be between 2 and 3 miles was really at least 50 miles. It is true that Lowell[8] did not accept Newcombe's conclusions criticising his method, but when he states that the curious phenomenon occurred also to him many years before, the psychological influence in such cases is even all the more confirmed.

In another direction Bauch[9] at the instance of Marbe concluded an investigation on the estimation of very small divisions such as tenths on a dial. He worked with an arrangement that had been expressly got up for the occasion and

[7] *Astrophysical Journal*, vol. 26, p. 9.
[8] Lowell: *Astrophysical Journal*, 1907. Reply to Newcombe.
[9] Über Beobachtungsfehler in der meteorologischen Praxis, *Fortschritte der Psychologie*, vol. II, 1914, p. 246ff.

which consisted of a vernier marked off into tenths in such a way, however, that the divisions were concealed from the view of the observers. After the hand was seen moving between two integers, the observers were asked to give their judgment while the experimenter could verify the actual tenth that the hand had moved to. As a matter of fact it was found that the tenths at the extremes were given preference over those in the middle. The tenths 1, 2, 8, 9, 0 received by far most of the judgments, while the tenths 3, 4, 5, 6 and 7 were more or less neglected. That seems to point again to Marbe's principle of the Uniformity of the Psychical Event and proves that even deviations from the actual facts are governed by certain psychological principles. This preference for the border tenths is sufficient to vitiate the results of the readings where a line may represent a distance of miles. By carrying on such investigations on an extensive scale with a large number of trained observers, it is possible to determine the extent of the deviation from the actual occurrence and so make allowance for it.

Prof. F. M. Urban[10] also undertook a series of experiments of a similar kind, and his results show likewise that there is a certain favoring with some of the numerals in the estimation of short time intervals while others are neglected. Yet the results are not quite the same as those of Bauch. It is quite probable, as Urban is led to believe, that each set of experiments would work out differently according to the conditions, but at least this is certain that in all those observations referred to there is a systematic error quite apart from the mathematical theory of Error.

This main conclusion is corroborated by the findings of Meissner whose results more or less coincide with those of Urban, and on the other hand by Hellmann, Obermayer and Plassmann, whose conclusions are nearer that of Bauch. It was also brought out in those investigations that some have a tendency to overestimate while others underestimate the time interval. Hellmann[11] thinks that in taking the readings of a barometer, thermometer or hygrometer, slips are constantly made. Very frequently a five is read for a ten, and vice versa, as the length of the stroke is not clearly apperceived. After examining the observatory records at Potsdam, Hellmann learnt that the even tenths of the barometers which are marked off in 1-5 degrees appeared a good deal more frequently than the odd tenths. The reason for this was that every reading, except where the hand was seen exactly between

[10] *American Journal of Psychology*, vol. XVIII, 1907 pp. 187-193.
[11] Cited in Bauch's Über Beobachtungsfehler, etc., cf. foot note 9.

the two 1-5 marks, would be apt to be noted as a fifth or even tenth, i. e., $\frac{3\frac{1}{4}}{10}$ would be read as 4-10 instead of 3-10. The same preference for the round number and more general term at the expense of accuracy was marked in the records showing the direction of the wind. The middle points, such as N.N.E., E.N.E., E.S.E. and the 5 others occurred far more rarely than the main directions N., E., W., and S. As Bauch suggested in the case of his own results, the preference may be due to a greater intensity of attention to the main directions.

Another source of danger for the astronomer was pointed out by Plassmann as consisting in not taking the reading at the right moment. He experimented on the estimation of short spaces with a Jensens Pendelquadrant and found that the readings or estimates must be made very quickly, otherwise the pointer or hand would be likely to slide somewhat away from the actual spot after some vacillation.

In the *Zeitschrift für Psychologie*,[12] the same writer reviews a number of errors caused by individual differences in stellar observation. He relates that red stars would appear to him relatively weaker than they did to most other observers. This underestimation of red was worst at the beginning. Gradually that impression would gain in hue, but the feeling of certainty was so lost to the observer that he jotted down the very first thing he was able to see. To show what factors may influence the astronomer he cites the figures for one observer. At one time the zero tenth was recorded 139 times, which means that it occurred the most frequent among all the tenths. Later, however, the zero tenth occurred only 59 times and was by far the least frequently recorded tenth. It was then revealed that the observer had favored the zero tenth and later tried to avoid the preference with the result that he unduly neglected it.

No less instructive is his more recent investigation on periodicity in the variability of the decimal error,[13] in which he shows by tables based on 13 years of observation (1904-1915 inclusive) that (a) the odd tenths on the astronomical clock are apt to be slurred in favor of the even decimal (b) the overemphasized tenths display a decided periodicity effect. The last conclusion, which is amply proven by Plassmann's tables, is an altogether new datum in the psychology of quantitative observation, and is of especial importance for astronomy.

[12] *Zeitschrift für Psych.*, vol. 49.

[13] J. Plassmann: *Zeitschrift für Psychologie*, vol. LXXVII, Dec. 1916.

Astronomy was the first of the natural sciences to pave the way for applied psychology, but there is no reason why it should be the only science in that group to require the assistance of psychotechnics. Since physics is so much allied to astronomy, it is impossible for the physicist to feel immune from psychological errors, after the astronomer has been shown to be subject to misobservation, misreading, misinterpretation, misrecording and many other mistakes.

One instance which must be borne in mind by physicists is given by Marbe[14] when he says "If the perception of differences is much easier for very slight and very intense stimuli than for those of medium intensity, it would be necessary in physical readings to select the stimuli to be compared from the middle of the intensity scale." This consideration, he goes on to say, would be important in photometry where two lights of great intensity might have to be reduced in a certain relation. Nor can physicists afford to ignore the phenomena of after images, contrast, induction, and so forth.

In a large measure the physicist's work is similar to that of the astronomer. He too has to estimate space and time intervals, take readings, record colors and the like; and so what has been said above under the head of astronomy will largely hold of the application to physics as well. The physicist has even to employ more senses than the astronomer who has nothing to do with the kinaesthetic or tactual sensations. With all the instruments and appliances at his disposal, the physicist still makes use of his senses in the rough work. It is only when in doubt that he really goes into an elaborate examination. The danger, however, is to be found in the countless instances of certainty which may only express a certain feeling, but does not reveal the actual state of affairs.

Practice, of course, is the great asset of the naturalist, and the question may be raised whether continual practice may not make one a better observer. Meissner's results showing that the one observer who was the most constant was also the most experienced seem to point in that direction; but the whole question can have a pedagogical value only. As a matter of fact he who has a leaning for the natural sciences must surely have his powers of observation well developed. The probability is that he is always in practice, and that the institution of such a discipline would be mere child's play and superfluous for him, although it might help the other children who are less endowed, and even here Baade in his "Aussagen über physikalische Demonstrationen," denies that there was any improvement in the attestation ability of the

[14] Marbe: *Fortschritte der Psychologie*, vol. 1, 1913.

children who had had the benefit of practice and correction. He even goes so far as to say directly that the "occasional apparent instances of improvement must, in part definitely and some of them with great probability, be traced to factors that have nothing whatever to do with practice or the education of the knack for attesting correctly."[15]

In chemistry, as far as I know, no work has been done to show the relation between that science and psychology. The only reference to the application of the latter to the former is found in Münsterberg's *Psychotechnik*, and the following sentences are largely a résumé of a paragraph or two of the book.

The chemist, like the physicist, has many objective criteria at his command, it is true, but finally he must resort to his senses; and the senses to which he appeals are even more in number than those the physicist has occasion to employ, for not only must he use his eyes and fingers and possibly the ears, but has also to gain most of his information through the senses of smell and taste. Of course the chemist has his test-tubes and his formulae, but these are no good to him unless he has full possession of all his senses.

In this respect the following quotation from Münsterberg's book is significant. "When the chemist, let us say, finds that the intensity of the sour taste does not altogether correspond to the chemical grade of acidity, it will be due to purely physiological conditions at the surface of the tongue, whereas the after-effect and combination of tastes which is so important for the chemist might readily lead us to the psychophysiological." But that is not enough, we are told a little further. The chemist like the psychologist must be aware of the fact, e. g., "that the perception of humidity may come about through the touch and temperature sensations without there being any objective stimulus of dampness at all; or that the impression of softness could be got from a hard surface if the skin-spot that is brought in contact with it had first been rubbed against a rough surface."[16]

When we come to think of how much pains chemists have taken to know every detail of all the material they employ, while taking no account of their internal instruments, the sense organs, it is astonishing. The time is yet to come when an accident, such as the disagreement of chemists on matters of fact, will lead to the belated recognition of the value of applied psychology for chemistry.

[15] Baade: Aussagen über phys. Demon., *Zt. für angewandte Psych.*, vol. 4, 1911, p. 281.
[16] Psychotechnik, p. 683.

In geology there are fewer chances of going wrong on the pure data, but to make up for this, there is a great scope for interpretation, and that means that wrong interpretation is just as likely to trap the geologist as the correct one. Where reconstruction plays a great part, as in geology and many branches of zoölogy, one must be on his guard against unwelcome influences such as suggestibility, imagination, and other purely psychological factors which will be mentioned later. It is very easy to mistake certain marks for fossils or footprints, if one has a pet theory that he wishes to be confirmed. It is perhaps well for an Agassiz to reconstruct an animal out of a couple of bones, but how many are there who nourish their extravagant views by making use of doubtful results?

As for geography, topography, and physiography, psychology can do distinct service in this field in spite of the many measuring-instruments that are to guarantee the accuracy of the records. Of course the measuring of mountains by the aid of barometers and trigonometric calculations has all the advantages that modern science could offer, but the traveler has to judge and make estimates at a distance many times under the most unfavorable atmospheric conditions, and it is here that he encounters difficulties, difficulties which psychology might not obviate, but, at least, it would help to make him more circumspect.

Before one is about to examine a particular locality in detail, he must decide beforehand whether it would be of any advantage or expedient to examine that place, and that he must do at a distance, making a number of estimates. His field glasses and other instruments may be of great service to him, but they would not rid him altogether of some illusions. The illusions may be due to the overestimation of the vertical lines as against the horizontal ones or vice versa. They may be caused by incorrect impressions of background, slopes, colors and many other wrong perceptions.

It is interesting to note in this connection that Münsterberg was struck with the singular difficulty in estimating correctly the height of certain points facing the traveler while descending or ascending a slope. This formed the starting-point for an investigation on the Subjective Horizon carried out by Robert MacDougall. According to MacDougall, the plane is "determined by the positions of the observing eye and the perspective focus. Spatial relationship becomes a temporary subjective horizon."[17] In his experiments, MacDougall introduced at one time a descending plane, at another, an ascending

[17] *Harvard Psychol. Studies,* vol. 1,, p.. 166.

plane. The former led to the lowering of the apparent horizon, while the ascending plane did the reverse, i. e., it elevated the horizon. The results seem to explain why the area of a level ground at the foot of a hill when one is descending it is always taken to be an opposing rise.[18] There are a host of other problems that could be taken up in a similar way and worked out in the laboratory for the benefit of the geographical sciences.

There is no need to refer at present to mineralogy or zoölogy and botany in particular. The methods of these vary but little from those of the other natural sciences, and so the conclusions arrived at already might be applied *mutatis mutandis* to the former.

The physician, too, has not a little to learn from psychology. In the "*Psychotechnik*"[19] our attention is drawn to the fact that where slight tumors or swellings appear as symptoms, it may be a serious matter if the physician could not determine their nature and should allow them to develop until it is too late. Of signal importance for the practitioner is also his ability to use the stethoscope and stethometer and go through the percussion in the most satisfactory manner so as not to endanger the life of the patient. The same holds true in measuring the pressure of the blood or in feeling the pulse. Not alone the ears and fingers must be in sound condition, but the physician must not allow himself to be disturbed by psychological factors.

In anthropology Marbe mentions the work of Myers and Rivers among the Torres Islanders. It is difficult, however, to see why anthropology should be called a natural science any more than a psychological. The pure bodily measurements are it is true physical, but they have no value unless psychologically correlated and explained.[20] You can study the structure of any organ without requiring to know anything about the psychology of the organism, but in order to measure the cephalic index of people, you must set out with certain psychological data from the persons you are measuring; for instance, when Boas tells us that the heads of new settlers, in the second generation, tend to take on the shape of the native American heads,[21] the statement is uninforming unless we know the psychological status, the mental make-up of the

[18] Ibid., 163.

[19] Psychotechnik, p. 685.

[20] Boas ("Psychological Problems in Anthropology," in *American Journal of Psychology*, vol. XXI, 1910). emphasizes this point theoretically; yet it seems he does not adhere to it in practice, as will be seen presently.

[21] F. Boas: The Mind of Primitive Man, Chap. II.

subject. The subject may have become totally assimilated or he may have clung steadfastly to the traditions and culture of his own nationality, and it makes quite a difference as to which it is. A crucial test of the situation would be to compare the children of thoroughly Americanized foreigners with those of unassimilated immigrants of equally long standing. Besides, a certain type is correlated with a certain people showing that the anthropological data are to be guided and confirmed only on the basis of psychology. That, however, is a side issue.

In addition to the psycho-physiological influences and sources of error, we must not forget the purely psychological factors. Scientists are just as liable to succumb to suggestion even though of an impersonal nature, to lapses of memory, lack of attention, etc., as is the layman. They may have their individual prejudices and, as a consequence, anticipate things they like, or fail to see objects to which they are averse just as much as the ordinary man. Münsterberg observes that some investigators may even be subject to a degree of suggestibility higher than the normal. It is only thus that we can explain the susceptibility of men like Sir Oliver Lodge and Sir William Crookes, to spiritualistic phenomena.

It is clear that the dictum "Know thyself" applies to the natural scientist in just as equal a measure as to any other man, and perhaps more since it is only by knowing himself that he can know his science. In an experimental study of Belief,[22] the fact was revealed that the trained psychologists rated their beliefs more consistently and in general, their results were more satisfactory than others who had acted as subjects. This suggests according to Sumner that the good introspector knows more about what he believes than the poor introspector who states generally what he thinks he believes.

So far we have dealt only with the individual differences or general deviations in particular respects. We must now approach the subject from a slightly different angle. The upshot of all that has been said above is a warning held out to the investigators of natural science, a warning that is sure to be well taken by all scientists. Prognosis here does not hold except in the sense that if one takes heed of the warning, his result will be more accurate than if he did not; but that is a truism. There is no definite forecasting about that.

It is possible, however, to regard scientists as members of a class or group and treat them under the heading of "group psychology." The fact that one is a naturalist means

[22] Study of Belief. *Psych. Review*, 1898, vol. 5.

that his psychical equipment is of a similar kind to another who is in the same field. One does not accidentally become a physicist or chemist, as is the case with tradespeople, and even tradespeople have certain features in common that they may have acquired.

If then such types should really be discerned among the scientists we should gain a great deal not only for collective psychology, but for pedagogy and science as well. The rôle of prognosis here is very marked, for when we do come to the conclusion that X is of such and such a type, we might know just what kind of a science he is most adapted to. We may possibly be able to tell what X's views will be in other branches than his own and so make allowance for the type prejudice. In short we should know just how far to follow a particular investigator and where to stop.

Generally speaking, it seems that types of scientists do exist. The philologist is a different sort of an investigator from the physicist or chemist. The latter are more prone to positivism through metaphysical skepticism. That there is some basis for a division into types can be inferred from the phrase "*Scepticisme du savant*" which is practically identical with positivism. An extensive study of applied biography in the sense that Ostwald's book "Grosse Männer" may be considered, would settle no doubt the question for us. At present one cannot help noticing that our great naturalists seem to avoid the plateau of pure metaphysics and epistemology. Instead, their temperamental skepticism leads them either to soar to the heights of spiritualism or else to precipitate themselves into the abyss of materialism. They scarcely see any middle course open to them. The world of pure concepts has no charm for them.

Is it not characteristic that Huxley, Haeckel, Mach, Hertz, Kirchoff, Verworn, Ostwald, Jacques Loeb should emphasize the materialistic side of philosophy, while again on the extreme opposite we find even more illustrious names from Pascal down to Lodge?

Another classification may be had on the basis of race or nationality. It is said that science has no nationality. This is quite true, but *scientists nevertheless show the distinct characteristics of their people in their works.* That phlegmatic England should produce a Darwin and Wallace, a Newton and a Faraday all of whom would correspond to the classical type of Ostwald's classification, is worthy of mention.

Other divisions have been suggested among the naturalists. In mathematics, Poincaré[23] tells us, there are the logicians

[23] Poincaré: Value of Science, p. 15.

who advance only step by step like Méray who even sets about proving that an angle may be subdivided, while on the other hand there is the intuitionist who makes "quick but precarious conquests." It would therefore be very important to know which is which, so that we might benefit by the breadth of view of the latter and the impeccable accuracy of the former.

Ostwald's division of great men into two types, the classic and the romantic, is also valuable for the same reason. It furthermore gives us a clue to a whole department of cultural and distribution. If the romanticist is the more stimulating, the more interesting of the two, and exercises the greater influence over people, he ought to be the teacher, while the classic type should do all the research and direct the laboratory—work in which accuracy and rigor deserve the premium. Ach's[24] adoption of the old 4 types of temperaments. with the addition of a fifth, the *besonnene* type, may be reduced to Ostwald's two types, although the information Ach gives us on the inner determination of each of the five types must not be neglected in estimating the reliability of a scientist's work. Several other classifications have been proposed, including Buckle's into synthetic and analytic or deductive and inductive types, but the point is not to obtain suitable names so much as to ascertain what psychological factors constitute the differences in the various types.

Nor again does the fact that one belongs predominantly to a certain type detract from his work. The view of Poincaré that the "two sorts of minds are equally necessary for the progress of the world" is beyond question. Since it is not given to every scientist to develop the perfect blend of types, the next best thing is for every one to cultivate the type that is natural to him as well as he can. The division of scientists into types may not have any influence upon the scientists in the way of correction, but it would act as a guiding star in *making decisions* upon the views of others.

We see, therefore, that while earlier in the paper, the psychologist was represented as addressing himself to the scientist with a mere warning, he now does not venture to correct the scientist as to his temperament. Such a course would be neither right nor useful. Cattell in his "Statistical Studies of American Men of Science"[25] aptly remarks that whereas very many complain of having a bad memory or other defect, we seldom find one who deliberately owns up to a defect of judgment. The reason for this difference, I

[24] Ach: Über den Willensakt und das Temperament, last chapter.
[25] Science, 1906. 3 articles.

think, is obvious. In the first place, a defect of memory is easily proven, while bad judgment, on the whole, is something that does not readily lend itself to conviction, because there is no definite standard for judgment, in the first instance. Secondly, the faculty of judgment seems to be the *expression of a man,* something he identifies himself with, and so he regards his own judgment as good as the next man's. The same holds true of temperament. Although every man might think it ideal to possess a harmonious combination of both the classic and the romantic temperaments, it need not surprise us, however, that the one of the classic type regards himself as good as the other and vice versa, and with reason.

In this matter, then, the psychologist has nothing to do with the scientist as representative of his own science. He now gives his results to the world at large; and these results, after the question of types is carefully studied, would have to be more definite than the mere "Beware" he held out to the scientist. He now not only picks a flaw, but states what may actually be expected under the conditions. Here we have a certain prognostication, but here there is also a human objective—the naturalist, since the applied psychologist sets up an interaction between the personality of the naturalist and that of his students. The human relation and prognostication go together as suggested earlier in the paper.

HUMAN ENGINEERING

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This country which for so many years seemed blessed with unlimited resources is finding itself checked for lack of human power. We have perhaps led the world in what are known abroad as "Yankee tricks" in industry and agriculture, which consist for the most part in the application of mechanical devices to work which might otherwise be done by hand.

In spite of this the development of our natural resources has made necessary the importation of great numbers of workers from other countries less fortunate in their natural possessions. We had assimilated the races of Northern Europe and were becoming accustomed to those from the South and even the East, when the World War placed an embargo on these importations.

Previous to that time our treatment of workmen was on a par with the utter wastefulness with which we cut down our forests and mined and cultivated only the richest lands. If a workman decided to leave us on the impulse of the moment, or if a foreman showed favoritism, or was arbitrary and unreasonable we simply shrugged our shoulders, admitted that it was wrong, and went on our way undisturbed, knowing that a dozen men were ready and anxious to step into his place.

Today all this is reversed. Employers are wondering where the workmen are to come from for the natural growth of business, to say nothing of those for large extensions they would like to build. They see still greater difficulty as the country is drawn into the war, and they see no relief with the coming of peace. The rebuilding of what has been destroyed will demand all the labor of those who live to be released from military service. Women who are content to work in shops to relieve the strain of worry about dear ones in the fighting line will return to their natural functions. Men will follow their natural longings and will return to the lands of their youth.

This leaves us only the Chinese and East Indian races from which to draw additional labor. Neither of these races assimilate readily with other races even in this vast melting pot.

Our greatest source of labor lies in making that which we have doubly efficient.

A few years ago this coming need was seen and partially met by a few men under the leadership of Dr. Fred W. Taylor and christened "Scientific Management." Dr. Taylor showed the enormity of the waste due to inefficient methods and incomplete mechanical aids to doing work.

He however almost entirely ignored the human element or at the best dismissed it with the thought that any desired result can be obtained if the worker is given a slight increase in wages.

It is only within the past three years that the great waste due to the thoughtless hiring and discharge of employees has been seriously considered. It was found that men average to stay less than a year on each job. There are approximately 40,000,000 working people in the United States and nearly 50,000,000 changes in work each year each of which calls for a considerable expenditure in training for the new job. The cost in wages lost, in spoiled work, in time of foreman or instructor consumed, ranges from less than ten dollars in the case of a laborer to a thousand dollars or more for men in executive positions. If we assume the average cost of changing jobs to be $25, which is surely conservative, the loss to the country is a round billion dollars each year.

This loss can be reduced. It ought not to be cut down to the point where promotion is discouraged, but there is a large range of inefficiency before that point is reached.

The first essential to stability of employment in any firm is that there shall be a constant and sufficient supply of applications for work so that a proper selection may be made for the various positions which arise.

The best class of men are careful in choosing the place where they will work when circumstances allow it. They are more apt to be influenced by what people who are already working in that plant say to them than they are by advertisements. While advertisements draw considerable number of people they are very apt to draw the class known as floaters and others who are by no means desirable.

From this it is easy to determine that the first essential is that the shop shall be comfortable in both a physical and a mental way. Good, well lighted buildings, as clean as the work allows, well ventilated, warm in winter, cool in summer, plenty of machinery and tools for the comfortable production of work, foremen and associates kindly and just in their action, all make a shop attractive; but even when men are working in a shop where their only contact with each other and the

management is through their work, there is danger that each will get wrong impressions of the other. To offset this there is a real necessity of a semi-social contact in which entire democracy is evident. Such activities as ball games, both inter-departmental and outside, dances under proper care, parades and picnics, in which the management and office mingle freely with the shop and which permit of a spirit similar to that found in educational institutions and expressed in shop yells and celebration of victories, have a value which is evidenced by an immediate increase in the number and quality of applicants for jobs, which in itself almost justifies the expense which such things involve.

Having secured an abundant supply of people from whom to select, the next problem is to select the men for the jobs which are required or to find positions in the shop for those who come who are especially likely appearing people. Various methods of selection have been proposed from time to time, varying all the way from palmistry and phrenology to psychological tests. Most of these are reluctantly received by the average employer who still depends on what he chooses to term "common-sense."

Common-sense reduced to scientific terms becomes a matter of judgment from historical records, that is, the assumption is made that a man who has worked at a given kind of work, has been successful at it, will probably be successful in similar work or if he shows signs of initiative and activity coupled with a spirit of co-operation may be expected to hold positions somewhat more important than those which he has held in the past.

Above all things the employer wishes to know what the *attitude* of his employee is toward work. A man whose questions indicate that he does not want to come too early in the morning nor stay too late at night, or who is too particular about the specific kind of work which he shall do, is apt to be looked on with some degree of suspicion. If, on the other hand, the candidate shows that he has thought the matter out and has decided that he wishes to work for the company to which he is applying and is willing to take some sort of a position, even though it might not be the one which he would like, in the belief that he can make it lead him into the kind of a position which he wishes, then it is almost always safe to assume that the company can afford to employ him even though they may have to make an opening for him for the time being.

Knowledge of the work to be done is of varying degrees of importance according to the department or the kind of

work which it is expected that he will undertake. In some places it is really more important that the man shall come with an open mind not influenced by previous experience in that particular work and yet in still others it is possible to find men whose training either at school or in a trade school has been such as to make him immediately valuable in many different lines of work.

It is the custom in many places to analyze the jobs in each shop with the idea that the person who is doing the selecting of help will be guided by those analyses. It seems, however, much wiser that no one should be allowed to make a selection of employees who is not sufficiently familiar by actual personal contact with the work which the employee is to be called on to do, so that he can tell without hesitation whether the man who is applying could be expected to do the work successfully or not. In any given concern if the men who are doing the hiring are skilful at the trade which is the most difficult to learn, they will usually find very little difficulty in securing sufficient familiarity with the other trades, so that their selection can be made readily and with a considerable degree of security.

After it is determined that a given applicant has a sufficient knowledge of the work, if any is necessary, the next thing which is sometimes considered is his *activity*. There are of course many positions where an active man will not be contented; there are many positions where all that is required is his presence. He must be able and willing to act when the time comes but the rest of the time he is simply waiting. On the other hand, in manufacturing industries especially, it is necessary that the larger proportion of men have considerable activity. This can be judged in the new candidate by observing the way in which he acts while under question and, barring a tendency on the part of some to a nervous activity temporary or permanent, there is little difficulty in judging this point. Again, an active man will usually show in his records that he has worked the longest on jobs requiring some considerable activity; while the inactive man will also have stayed the longest on jobs which did not require much action.

The *initiative* of the applicant is something which is rather difficult to get at, but it can usually be discovered by engaging the man in conversation and finding out what he does of his own volition. The use which he makes of his leisure time is oftentimes indicative of what he would do if he were in business for himself and what he will do in an emergency for the people who employ him. Here again the amount of initiative must be tempered somewhat by the position which

is to be filled, for example a man of high initiative would not be successful as a watchman because he would not be contented there nor will he be contented in work of a routine nature where the repetition is constant.

Again the employer is very much concerned with the probable *loyalty* of his workmen. It is generally accepted that a man who will stand by the concern with which he works is more valuable than the man, no matter how brilliant he may be, who is all the time thinking of ways in which he can get even with his employer. This is, however, easily discovered by inquiring as to his feelings toward previous employers. We of course are willing to allow every man one or two previous employers for whom he has comparatively little use, but if we find that his attitude toward all previous employers is that they did not treat him in the right way, we cannot help but feel that he probably will think the same of us.

Courtesy is another element of really considerable importance. While it may seem as though a man working at a lathe or bench might be fully as valuable to us even though he were discourteous, at the same time the efficiency of the shop as a whole is lowered by too great a number of men who are habitual grouches. A shop where everybody is feeling good natured can be keyed up to pretty rapid production without tiring the men or without their feeling that they are in any way being driven, while a shop which is not good natured, where the people are all the time suspicious of each other and of the firm, cannot be expected to manifest nearly the efficiency of the other.

Sobriety. It goes without saying in these days that no employer wishes to have any of his men under the influence of liquor either while they are in the shop or at any other time, because we all realize now that a man is stupefied to some extent even by what is known as moderate drinking, that is, if a man is a habitual small drinker and is capable and well esteemed it is pretty certain that if he could be persuaded to abstain entirely he would be of much more value to his employer. Sobriety can only be judged by past records except as the man may be thrown off his guard somewhat when he is asked about it. Any man who is asked whether he is a drinking man or not will usually indignantly reply that he is not, whereas if he is asked what he drinks or how often he takes a drink it is very possible that he may tell the truth without thinking about it.

We also wish to be certain that whomever we employ is a *booster* rather than a knocker. The man who runs down everybody with whom he has had relations, who slurs the

people for whom he has worked, the city in which he lives and all of his relations, is in very great danger of doing the same for the new concern which hires him. As a usual thing, if a man is a knocker it comes out in the course of conversation without any direct questioning, but in some cases a word or two will let loose the torrent and we find out immediately just what kind of a man we are talking with.

Again in a great many cases we are very much interested in the man's attitude toward improvement, his *ambition,* whether he is willing to do anything himself to improve his condition or whether he is one of those who are content with what they have and wish for nothing more. There are, of course, a great many places where the latter class of people are the only ones who will stay long on a job, and it is for that kind of a job which we must select them. On the other hand, we all wish to have among us a considerable number of people whose willingness to improve themselves is not only good but who will make the effort on their own account to do so. A man who will take a correspondence course probably has this quality, even though we may suspect that his work may not have given him the benefit which he expected when he took it. People who have attended night school for any considerable length of time have most certainly a considerable degree of willingness to improve themselves, and it is certain that they have made considerable sacrifice in order to do so. Such men are probably likely to make considerable effort to better their condition when they are working for us.

Stability, the one thing for which we have been searching through all this inquiry so far, is of course dependent to a considerable extent on the surroundings in which the man finds himself; but even in the best of surroundings a man who has previously been going from one job to another without any apparent settled purpose, is very apt to go from us to the next firm with as little provocation. On the other hand, every reason which he gives for moving from one place to another should be given full weight, for there are, of course, a great many times when a man secures a much better opportunity soon after he has gone on a new job. On the other hand, a man whose stability is evidenced by having worked for a given concern for a great many years where there has been no change in his work, is always more or less of a dangerous man to employ because he is apt to become homesick and wish that he was back on the old job where he did not have to think about anything new. However, enough such cases turn out well so that not too much attention should be paid to this point.

When the new man has been selected, that is only a beginning and does not determine how long the man may stay with us. In order to insure that he is placed in a position which he can hold with comfort and satisfaction to himself, it is highly desirable that he be given a thorough physical examination which will point out any *physical defects* which a certain kind of work might accentuate. If such defects are found, it is necessary to select for him some other kind of work than that first intended which will enable him to be comfortable while working. A man with flat feet should not be placed upon a standing job unless he is provided with suitable plates; a man who has heart disease should not be placed where he will have to work in the heat or where he will have to make sudden exertions; men with hernia should not be allowed to take positions where there is heavy lifting, and so on covering the various and common human ailments, many of which are unknown to those who are afflicted with them and many of which men will conceal if possible in hopes of getting by and getting a position which will give them at least a little temporary work while they are looking around for still other employment with somebody else.

After they are placed on the job it is necessary to *follow* them *up* and see that the work is proving itself suitable for them and that they are adapting themselves to the work. This can be done either by asking the foreman under whom they work to give his opinion as to their capacity and their degree of co-operation or it may be done by some person from the employment department who approaches the matter perhaps with a little less bias. The combination of the two is the safest.

It is generally accepted that a man who is a failure in the first department to which he is assigned should be given an opportunity in some other department. It is not always the man who is physically or mentally fitted for a job who succeeds, because we have also to deal with the *disposition and tendencies of the foreman* with whom he comes in contact. Some foremen are constructive and are able to develop the best there is in men who come under them. Other foremen tend to break down ability rather than to build it up. Men of the latter type must be furnished with workmen who are of exceptionally strong characters and almost stubborn in their natures, while the first can use men who build up the organization of the concern by making more and more out of the men under him all the time.

In addition to the following up of the men inside the works, it is also desirable that men absent on account of accident,

absent from work without notice and sicknesses should be followed up by some one representing the employer who will take an interest, which will not however be paternal in any sense, in the man's welfare. This interest is surely a business one and one which after a little time becomes accepted by both the company and the employee as a matter of fact and nothing to be at all surprised about. It is the kind of interest which the employer himself took years ago when his organization was small enough so that he was personally acquainted with all of his subordinates.

A great deal is being done to *improve safety* in our shops. Much of it is prompted in spite of the considerable expense incurred, by the compensation acts in different states, but it has an equally important bearing on the relations of the company to its employees and their length of service. It has been found that less than one-quarter of all the accidents which occur are preventable by means of mechanical safe-guards, but it is necessary that they shall be furnished as an evidence of good faith on the part of the employer, showing the workmen that it is his intention to do his part towards making work safe. Almost all men and especially those with families will greatly prefer to work in a shop that has the reputation of being safe, but a large part of real safety work consists in educating the men, all of them, in safe practises, and it is a part of the duty of a Safety Engineering Department to discover safe practises which are rapid and easily performed so that production is not decreased, for both men and employers are equally concerned that rapidity of production is as great as is consistent with good quality of work and long life of the employee and the machinery which he uses.

Other problems which confront the employer who finds it profitable to have his factory removed from the center of the population are those relating to *transportation, housing,* and *feeding*. It may be generally accepted that an employee considers his working day as lasting from the time he leaves his home in the morning until he returns at night and his idea of whether he is receiving good pay is based on the length of those hours rather than on the hours which he spends inside of the shop. Rapid and comfortable methods of getting back and forth from home to the shop then have a really considerable bearing on the rate of pay which is given. This involves three items; getting from work to the cars or whatever means of transportation is offered, quickly and easily, which often means that trains or cars must be run directly into the yard of the company so that the shortest space of time is used inside of the works. Then, securing

of seating capacity or nearly enough seating capacity to take care of all employees, especially when they are coming out in the morning and when they may lose considerable of their productive ability through becoming tired before they are able to work at all. The rapidity with which the cars move to their destination and the distribution of the men to their homes is particularly important, that is, a factory established in the outskirts of a town which has a good transfer system is better than one whose employees are simply dropped at a central point and must walk considerable distances to their homes.

Housing is of great importance because we realize that men who are able to secure suitable accommodations for themselves alone or for their families, if they have them, within walking distance from the work are very much more apt to become permanent members of an organization. It must be taken into consideration, however, that mere furnishing of housing facilities is not enough. The houses must be sufficiently varied in their architecture and in such surroundings as are attractive. The typical mill village of New England does not appeal to the class of people whom we desire. Again, it is necessary that any community shall have its opportunity for amusement. A village some distance from a large city which affords no moving pictures, no libraries, no dances, no socials, no soda fountain or any of the things which are attractive to both young and old cannot compete with a location nearer to the center of a large population.

Another matter which vitally affects those who are located away from the center of population is the *feeding* of their employees. A cold lunch brought from home is probably less expensive than any other meal which will keep a workman alive during the working day, but the low cost is often imaginary because it does not take into consideration the time spent in putting it up or the waste in strength from not having proper food in the middle of the day. Among brain workers it is an open question whether it would not be better to almost entirely omit the mid-day meal and consolidate the whole time in continuous work, but among those whose work is largely physical, it seems to be necessary that a division should be made and that enough food should be taken to renew the strength which was brought to the shop in the morning. The fatigue periods about 10:00 to 11:00 o'clock in the morning and 4:00 to 5:00 o'clock in the afternoon are quite readily noted and are being met in several places now by the installation of what are named "milk stations" or places where milk, buttermilk or some beverage like ginger-ale

can be purchased at cost or near it. While these fatigue periods occur at about that time, it is probably wise to keep these stations open from comparatively early in the morning until the latter part of the afternoon. Experience with these stations indicates that men do not abuse them, for they are largely patronized by men who are working at piece rates and who would not go to them if they did not feel that their production was advanced by so doing. Again, it is found that only a very small proportion of the people who use these stations take more than three drinks per day; the large majority taking two, one in the morning and one in the afternoon. It is also found that the very great majority of people drink either milk or buttermilk and only a comparatively few take ginger-ale or anything which is not highly nutritive. In some places chewing gum and chocolate is also sold, the chewing gum to take the place of snuff which is so often chewed in the shop, and the chocolate because it is both candy and food. The effect of such serving of milk during working hours has been quite noticeable in cutting down the amount of liquor men have gone out after. At the regular meal times there seems to be a decided advantage in giving men an opportunity to secure something warm in the form of a stew or a soup, or at least, hot coffee. This is of course particularly noticeable in the winter months when the additional nutrition is necessary. It is also wise to have the men go to certain eating places rather than allow them, as many will if they can, to hide themselves in corners and behind machinery so as to keep away from each other rather than congregating together. The little danger that there might be in having large numbers of men come together in one eating place that those among them who were in any way disgruntled, would start dissension which would spread among them may be offset by furnishing music or moving pictures or other entertainment of similar kind.

It is however, necessary that people be given the kind of food which they ought to have for the sake of building up their strength and also the kind of food which they desire and to which they have become accustomed through long habits. Some employers have even taken such an advanced position in this as to declare that it would be cheaper for them to *give* their employees the proper kind of food if they would eat it, than to *sell* them the kind which they wish to buy. Here again the effect is psychological, because people who are accustomed to eating large quantities of food do not feel themselves sufficiently well sustained unless their already distended organs are filled to the maximum, so that it is

necessary to furnish them with a considerable amount of chaff in proportion to the nutriment offered.

As suggested in the earlier parts of this article, in almost every industry considerable numbers of men must be employed who have had no previous experience in that industry. Various attempts have been made by the schools to supplement this work by furnishing trained mechanics. In some lines where the methods of a great number of shops are very much alike it is possible to give *fundamental training* which is equally applicable in all. On the other hand, there are great numbers of men who are employed in industries where the work is not merely practised in different ways in different shops but where the processes in each shop are each considered secret, and it is utterly impossible for the schools to find out what the employers wish their trained help to do. In all such instances as this where it is necessary either through lack of men sufficiently well trained or because the processes are different from those in other shops, it is necessary that the shop shall furnish its own *training department.* More often than not, however, this training is scattered promiscuously through the works and through the office and little or no attention is paid to it, because the owners do not recognize that their establishment is to a very great extent an educational institution.

If records are kept which indicate the men who are hired purposely to become learners, that is, men who do not bring with them specific training that is of value to the company, then it becomes evident that separate training courses are extremely desirable. These training courses may range all the way from one for operatives in a shop in which the men are taught a single operation and are expected to follow that to the exclusion of others during the time which they work for the company, up to those which involve a varied experience in different departments of the shop and in the office and which call for special training and special instructors for a given service. It has been found that men who are thus given a thorough opportunity to learn and know the work which they are expected to do and to know the reason why what is expected of them is required are very much more inclined to stay for long periods of time with the company which has paid that much attention to them. In other words, it appears to be provable that it is very much worth while to spend considerable sums of money in training men for the work which they are to do and also giving them a thorough insight into the relation of that work to the work which is done by others so that, in a measure they become a

portion of the company, understanding and comprehending its aims and aspirations.

Many firms have placed much faith in *life insurance* for their employees. The good intentions back of this movement and the very evident economy of insurance at wholesale rates should be provocative of good results. On the other hand, the cash value of such small policies as most firms have seen fit to issue is so small that workmen could hardly afford to lose a chance to earn more money elsewhere. There appears to be a feeling on the part of workmen that life insurance as offered by employers is a kind of bait which they distrust. This is not strange when we consider how much time and effort is necessary to convince well educated men to take out insurance.

Pensions also have a negligible effect on the present problem. They are so long deferred that they have no appeal to an employee during the part of his life when he is most productive.

Unfortunately, in spite of all our best endeavors men are leaving our industrial concerns in large numbers at all times, and it becomes necessary in order to reduce this large flow through our work to discover the *reason why people leave* and what may be done to cure them. In order to do this it is not enough to know the reason why the foreman in charge of a given room thinks his men left him, it is necessary to interview the man and to interview him in such a way that he feels confident that we are not inquiring into his personal affairs but that we have a real interest in his welfare and in those of the rest of our employees. Above all, it is necessary that every man who leaves shall, so far as possible, do it with a good taste in his mouth and in the belief that the company has seriously endeavored to treat him as it should.

Very often it is found, after making a study of the reasons why men leave a given department, that much of it is due to some cause which can be easily remedied, or, in other instances, causes which will be expensive to remedy but which the large number of men leaving and the cost of training new men fully justifies. For example, if it is known that during a given year a thousand men leave a certain department and it costs $50 each to train others to take their places, it is readily seen that an investment of several thousand dollars may be made in improving conditions in that department and still expect a very handsome return for the money expended. Such things however, when left merely to guess work and impression, are apt to have very little weight with the powers who have the spending of money.

Finally, a few men in every shop prove to have been unsuitable men or have changed their ways so that it is necessary to *dispense* with their services. This, however, is one of the things which should never be done in anger or in haste, but the men should understand that the action of their foreman in this same respect is subject to review, and if the foreman has been unjust, he will be persuaded to do what is right. When it is first proposed that the foreman's discharge shall not be final but that it shall be subject to review by some one else, there is apt to be a feeling among them that the sole prerogative which makes it possible for them to maintain discipline has been taken away. Experience, however, has proved that this is not so and that the foreman is in no wise handicapped but rather is aided because it makes it necessary or desirable for him to think twice before he takes this hasty action. It, of course, is necessary that the foreman be convinced of the error of his judgment before a man is reinstated in his department whom he has once requested be dismissed; but since the larger part of our troubles are due to the result of misunderstanding, if there is provided a neutral party, like an employment department, to which appeal can be taken, it is likely that misunderstandings will be readily straightened out and a much better feeling will prevail.

Fluctuation in employment has a most dangerous effect upon the men employed. If it becomes known in any shop or department that people have been discharged or laid off for lack of work, it is very probable that such a discharge will be followed by many resignations from people who are afraid to stay longer for fear that their turn will come next and who attempt to secure employment elsewhere where they have a feeling that their tenure will be longer. It seems to be a very wise thing in hiring people if it is known that their employment is only temporary that it shall be distinctly so understood at the start, and that everybody else in the department shall understand it that way so that when it becomes necessary to reduce the force, these people may be dispensed with without any upsetting of the feelings of others. Again, it is almost impossible for any man to accomplish as much if he sees the pile of work dwindling away and not being replenished. Under such circumstances, it is very easy for almost any workman to reduce his efficiency by even 50% without its being noticed by a foreman. Therefore, it seems very desirable and necessary that so far as possible fluctuation should not be allowed in a department beyond those which are taken care of by the natural flow of men through the

works. That is, if it is necessary that a given department should be reduced in numbers, it can usually be done by simply ceasing to hire new people and waiting for those who would naturally leave to get through.

From what has gone before, it may be readily judged that the work of the employment manager is one which really comprises a study of human nature all the way from the manager to the lowest paid worker. It seems to be very largely a question of knowing or judging what given individuals or groups of individuals will do under a given set of circumstances, and knowing from experience, which seems to be about our only guide as yet, what people have done under such circumstances, provide suitable means so that the circumstances and what follows from them may go along the line which will bring the greatest profit to the company employing the men. Temporary methods of stimulating production through bonuses or any other of the methods which have been proposed seem to be of comparatively little value in the long run, as men work after all, by the life-time rather than by the day. What we need to know is how much a man can accomplish from the time he should be entering the industry until the time when he should leave it. We cannot afford for the sake of making an apparently low record of turn-over from our shop to put up the bars in any way against promotion, nor can we afford to stand in the way of any one of our employees who finds a better opportunity in the work in the employ of our neighbors and our competitors. If he does find something better, we have only to look to ourselves and to discover what made it possible for him to better his condition there. It seems as if it should be possible for every plant to offer to its employees every opportunity for advancement or self-development while working under different foremen and heads of departments so that they would secure much of the variety which is obtained by working in different shops.

THE ATTITUDE AND THE REACTION OF THE BUSINESS MAN TO PSYCHOLOGY

Editorial Introduction. If psychology is to be of real service to workers in fields of practical activity, it seems essential that there should be the closest coöperation between these practical workers and the scientific investigators of the problems of psychology. Not only must the investigator make his findings more accessible to the world at large, but it is also important that the concrete problems of daily life, especially such as arise in the various fields of business and industrial activities, should be brought to the attention of the expert psychologist. Heretofore each business concern has attempted to solve its psychological problems in an off-hand way, and its solutions of these problems have been only provisional and tentative. In order to indicate to our readers what is the practical business man's attitude toward applied psychology, the editors have approached a number of leaders in the industrial and business world with the request that they give us an expression of their views regarding their problems and the methods they have developed in dealing with 'the human element,' or regarding any other aspect of applied psychology which seems to them to be of prime importance. We hope that the generous responses so far received, several of which are herewith presented, will stimulate others to do likewise; and that the discussion, which we hope will be continued in subsequent numbers of the Journal, will lead to a clearing-up of the various problems involved in the study of mental life as it manifests itself in our everyday activities.

THE HUMAN ELEMENT IN BUSINESS

By Professor HENRY C. METCALF, Tufts College, Mass.

The fundamental problem of the business world is the problem of men living and working together in reasonable harmony and progressive efficiency. Modern machinery as applied to the business world has caught us all in a meshwork of abstract power that has become dangerous. The crude, selfish era of industry from which we are now struggling to emerge has brought society to the most perilous situation in our history. Machinery has broken the brotherhood bond. This human bond must be restored in industry if society is to hold together. The commercialization of the human being must be counteracted. Abstract business power must be made not only scientific but human. This means a vast amount of reorganization, readjustment, regeneration and redemption. It means a proper understanding of man as *man* and a scientific comprehension of the whole problem of the human relations in industry. It means a full understanding of man's physical normal desires and needs—his physical wholeness—it calls for a clear perception of the meaning of his larger life which brings him into relation with his employer and fellow workmen—his organization fitness—it means a knowledge of his social body, which brings him into relation with society as an organism. It means an understanding of the spiritual which is the only real. In other words,

the fundamental organic unity of the worker and his organic progress in industry; the organic unity of the plant or firm in which he works; the organic unity of all business and the organic relations between business and humanity at large, must be understood and made a concrete asset before true harmony and real efficiency can be firmly established in business.

Now this is clearly a far vaster problem than any narrow school program can cover. Technical routine training for the various jobs, for transfer and progression within the business, for executive positions, is vital and necessary; but these are not the *real problems* confronting business, nor can these be successfully solved until men learn the fine art of *living together*.

The vital problem in business to-day is to develop growth in the capacity for, and to establish the machinery for practice in the habits of co-operation. This is the *internal problem of problems* confronting business to-day. To its successful solution all possible energy should be given. Everything else is subordinate to this. It calls for the most careful scientific self-analysis, self-direction, and self-control that all the forces of the business world are capable of commanding. To discover the men and to establish, maintain, advance and defend the vision, the ideals, the machinery and the interests for bringing this co-operation about is the great opportunity of organizations such as the National Association of Corporation Schools and the Employment Managers Groups. Business must get down to the great elemental truths of human nature. All the outward, heterogeneous complexity growing out of material and man's relation thereto must be brought into harmony and efficiency by the power of this unifying, inner living principle of co-operative adjustment. The truth in organic unity must comprehend and harmonize the confusing, balking and maiming multiplicity. Business is now crying out for the guidance of unified truth which governs numberless facts—a living, dynamic principle which shall liberate man's body, mind and soul. To make this ideal a reality in business is to awaken in every employee an eager desire to improve the quality of his *own* labor, which is the best asset any business can have.

Logically, therefore if such organizations as the National Association of Corporation Schools, and the Employment Managers Groups are to hold their well-earned leadership in the solution of the great problem of the human interpretation of industry, they must understand the organic nature of man and come to regard the business machinery as the greatest opportunity for the discovery, adaptation, instruction and training, protecting and justly rewarding human talents—in a word, as a vast capacity-catching and capacity-developing mechanism.

THE PSYCHOLOGY OF EFFICIENCY

By G. G. McCHESNEY, Librarian, Pierce-Arrow Motor Car Co., Buffalo, N. Y.

The human interest element in industry may be a new phrase, but it certainly is a crying need in the industrial world to-day.

Is there no inspiration in labor? Must the man who works go on forever in a deadly routine, fall into the habit of mechanical nothingness, and reap the reward of only so much drudgery and so much

pay? I think not. The times demand an industrial prophet who will lift industry off from its rusted, medieval hinges and put pure human interest, and simple, free-spirited life into modern workmanship. Nothing but human interest will ever awaken a task interest in the ordinary workman. "One of the inevitable results," says Charles L. Pearson, "of increased efficiency in manufacturing processes is the specialization of operations, increased monotony and more intense concentration on the part of the worker. Many manufacturing operations are continual repetitions with no decided change from one lot of work to another, the operator making a few different moves in rapid succession and repeating the operation all day or, perhaps day after day without much change. This class of work requires more or less intense concentration." A deadly monotony must inevitably follow. To put life into this death is the problem. Ever the source of life is life. Neither from the task nor from the machinery nor from the product, nor any other mechanical motive, can come any relief. Human interest alone can inspire a task interest. At the very point where the deadly monotony crucifies the task interest, must a living spirit resurrect a spirit and an interest superior to the monotony of the task. How is it to be done?

The very first element in an efficient management or an efficient supervision is the power to create interest. Is this too difficult? Walter Dill Scott says that the attitude of every man in an organization is the reflection of the dominating factor in the organization. To every workman there is a fascination in an interesting and interested leadership. Interest, like measles, is catching. The thing we would like to know is the psychological source of interest in the average workman. And we contend that you can no more inspire, resurrect, or create interest in a task by an absentee management or a supervision by proxy, or by cardboard, any more than you can hatch chickens from nutmegs. If efficiency is ever to take on real serious character and be measured, not by whim, or guess or conceit, but by living results, it must be borne in the heart, not the purse of industrial management; and it must permeate through and through the whole system of supervision.

The most efficient supervision must of necessity render the most humane service, and in every embryo this must take the form of human interest. In every form of sport, superior achievement and skill in performance are coveted and won by the greatest sacrifices of time and energy. Why not in industry? The answer is easy. Motive. Reward for skill. Praise for achievement. Merit well earned. Contest. Battles won with honor. The true sportsman is heroic. He is no slave. Can this spirit be put into industrial life? No. It cannot be put in. It can be born in.

James J. Hill of the Great Northern is a good example of how a man can lead his men in playing the game of big business. With only one exception he led his men without trouble in opening up the great Northwest. His ideal was service, not fortune building. Every man under him knew him as "Jim" Hill. They respected him for his superior grasp of railroading and for his personal interest in his men. The names of John Wanamaker and Henry Ford are splendid examples of how men breathe their own spirit into their organizations. If an executive is a man of vision, a man of broad sympathies and high ideals, a man of efficiency and energy of character, this entire force will be a wide awake body of live wires.

The spirit of efficiency must be back of all really efficient work. Better quality and greater quantity should be the aim, but not at the expense of life. Greater speed on the part of the workman will pro-

duce greater accuracy of workmanship. But the greater speed should be made possible by eliminating unnecessary motions, and by making necessary motions thoroughly automatic. The result will be a relief of drudging labor and the freedom of the man. Then he will be happy and work contentedly. Speed, skill, freedom, this is the order in the efficiency program.

A genius is a genius because he accomplishes more than others. In the last analysis genius is the power of achievement. But following the roadway backward from the result achieved to the home of genius, and then into his soul where his power plant of ideas and personal energy are stored, we find a most interesting problem. How does he do it? That is the query. That is the miracle. The miracle he performs is made possible to him because of his internal, subconscious energy. This energy is the product of an electric will which, working economically, has stored up power and systematized energy, often out of pure necessity, where it can be drawn upon at any time much as we draw upon a storage battery when in need of electric service. Many men are perfectly prodigal of their energies. The genius is not. All great men of the world have had their mental machinery well-equipped with energy, and the larger part of such machinery operating automatically. The genius operates both his mental and subconscious machinery to free his soul, making his body work for him under the most fascinating discipline. So we discover that the secret of achievement, or of efficiency rests on dynamic will power, together with a thoroughly trained subconsciousness. The more work we can do to-day, automatically, the more inspiring and creative work will become, the more of a man a man becomes, and the less of a machine. His subconsciousness acts with perfectly automatic precision. The mechanical element lies below the mental surface, so that really great achievement is the work of a free spirited man depending on his efficiently trained reflexive powers to carry out his desires. We call him inspired because he is both freer in spirit and more subconsciously mechanical than we are. Efficiency, therefore, must ever depend both on efficient desire, as well as upon the efficient organization of our reflex powers.

Every man should be more of a man, a better man, for having worked a day. The humdrum shop, operated by humdrum workmen, managed by humdrum superintendents, dominated by humdrum ideals, should be banished to Humdrum Land, if for no other reason than to save the men.

What is the man-making motive, and how is it generated, may I ask? In industrial life, who coins the man-making motive, and where is the mint? It must be acknowledged that the industries to be efficient must not be efficient at the sacrifice of men, but on the contrary, they must be efficient first of all in developing men, real men, men of heart and men of high character, before they have a right to be efficient either in business or in production. Doubt it do you? There are thousands of factories to-day running on an imaginary schedule of efficiency where men are robbed of the opportunity to develop themselves, where a business success is more of a hold-up game than a scientific, or economic process. I say a hold-up game because money can never be spent wisely and profitably where it demands the service of men, and at the same time imperils their character. Deterioration of men deteriorates profits. What shall we say then of the mental process of developing men, of growing manhood in the industries? How are men to know that they are growing to manhood while they work? If the larger opportunity is given to

industrial employees, and they know that the conditions and inspirations of industrial life make for better manhood will they respond to it? Will the response to such industrial inspirations react for higher daily task efficiency? One only needs to step into such factories as the Franklin Automobile Works, or the National Cash Register Company's plant to get a decided, positive answer.

Loyalty! Loyalty is inspired of confidence, confidence in men who believe in men, and who believe in God. No man over men who can damn his men has their confidence. And no plant operated without a definite welfare program can hope by a mere wage motive to win the loyalty of its working force. Every sensible man must realize the justice of being able to work at a man's job, under the direction of a manly man, at a man's wage, with a manly confidence in the heads of his concern. Many an industrial concern to our knowledge is running the gauntlet to-day of a perilous turnover, hiring ten to fifteen thousand men to maintain a force of five thousand. And why? Confidence. Loyalty. There you have it in a nutshell. Concerns that have the power to inspire confidence know little about this vexing problem. Men, like plants, grow in a healthful atmosphere. And, given an inspiring industrial atmosphere where man-timber may be grown to its richest and best, the fruit of contentment must inevitably follow. Manliness with contentment is great gain. We can but hope that the day is not far distant when the greater industries of our country will be operated first of all for turning out full grown, high charactered, industrial workmen, and incidentally and necessarily, most efficiently their material product.

INDUSTRIALISM AND APPLIED PSYCHOLOGY

By Paul Kreuzpointner, Altoona, Pa.

The reader will be led by the title of this article to inquire: What is the relation between industrialism and psychology? And what do we understand by the term 'industrialism'? The practical application of steam and electricity, together with scientific discoveries and mechanical inventions, have made it possible to control the forces of nature in the interest of humanity and for the service of mankind; and just in proportion as these practical applications have been made, it has been possible to develop a country's resources, and to feed, house and clothe a greater number of people. The increase in population has in turn given rise to a necessity of mass production and mass transportation, in order that the ever-growing multitude of peoples may be kept alive, and in order that their activities may be regulated. Mass consumption has necessitated mass production; and mass production in turn has necessitated the concentration of large groups of men and women at suitable localities, subject to centralized authority and military discipline, in order that the group should be kept active along required lines for united efforts. But this mass production and mass action have wrought a change in our traditional conditions of life,—social, economic and ethical,—in a way which is directly ascribable to the development of our industries; and the social-economic results which have arisen from these extended and concentrated industrial activities are expressed by the term 'industrialism'.

In consequence of its effects upon the intellectual, ethical and physical life of the people, this industrialism is responsible for a thoroughgoing change in the mentality of all the people; this change, however, is greater in the case of the industrial and urban population than in the case of the agricultural and rural population. In the interest of applied psychology, it is well to recognize that there are two phases in the influence of industrialism upon the mentality of the people: There has been a change in the old established mental habits and processes which were the result of our pioneer life and of the agricultural state of our pioneer society; and new mental habits have resulted from the intensification of our modern industrial and economic conditions.

Any one who had the opportunity, forty or fifty years ago, to observe the mass action of young people who were already engaged or intended to engage in industrial pursuits, will testify to the fact that a transformation of mental habits and mental activities has really taken place. In 1873 the writer, at the age of 31 years, became a pupil of the State Normal School at Edinboro, Pa., during the widespread financial panic of that period; it was not his intention to become a teacher, but being thrown out of work by the panic he simply desired to improve his education. In 1874, when living at Erie, Pa., he induced the school board of that city to open a 'Free Industrial Evening School,' the pioneer school of this sort in Pennsylvania; and he had charge of that school for three years, until a new school board closed all the existing evening schools. Having kept in close touch with the American youth ever since, both in shop

and in school, the writer has during the past ten years frequently expressed the opinion that the American boy of to-day is not so mentally alert nor so keenly observant as the American industrial boy of forty or fifty years ago. Why this change? Fifty years ago we were still close to the pioneer conditions of American life; and the mentality of the American youth of that period still reflected the mentality of those pioneer days, industrialism having not yet had time to make itself felt Our youth of that period were consuming the inherited stock of self-reliance, of individual courage and quickness of perception in danger, of self-respect, and of independence of action; and that ubiquitous and unique product of early industrial life in America, the 'Jack-of-all-trades,' was still flourishing in our midst. Now, after two generations of mass production by means of machinery, of automatic appliances, of military regime, and of consequent repression of initiative, this formerly virile product of pioneer mentality has been reduced to the status of a mental and physical automaton, whose activity consists in feeding his machine or in computing long rows of figures by means of a machine, with a minimum of mental exertion. Modern industrialism, spurred on by an ever-growing economic pressure, intensifies the effect of these mentally deteriorating influences upon millions of individuals in shops, stores and offices,—a state of affairs which induces mental stagnation and produces human automatons.

What is to be the end of it all? Can civilization survive such a stagnation of mentality? Here is where applied psychology should find a fertile field for cultivation. Thus far the science of psychology, in so far as it has attempted to be practical, has devoted itself to the task of finding the round peg for the round hole; and this attempt at vocational guidance is essentially an attempt to select suitable material to perpetuate the process of feeding the industrial and commercial mind-killing machine. Is there not a danger that in time, vocational guidance will become a part of the industrial machine itself? The work of the vocational psychologist, however, is not to be criticized or discredited; it is necessary, and we mention it here only as an illustration of the way in which increasing economic pressure compels industrialism to levy tribute on all of the sciences in order that its efficiency may be maintained and increased.

Here, then, we come to the crux of the question as to what is the function of applied psychology. What can applied psychology do to prevent or at least to minimize the mental deterioration of those for whom it has found suitable niches in the industrial machine, in order to prevent the social organization from degenerating to a lower mental level than is necessary to maintain orderly government and a progressive civilization? What is to be done in order to avoid the undesirable state of affairs that scientific psychology should unwittingly contribute to this mental degeneration by turning its expert knowledge to the task of picking out suitable material to fit as cogs into this mentally atrophying industrial machine?

Applied psychology must consider three distinct but closely interwoven phases of modern life. These three phases, working silently and insidiously, though none the less effectively, are the results of the reactions of modern social-economic organization upon the social-ethical life of the peoples of industrial nations. These results have been observed in Germany and in other industrial countries, where, however, they are found to vary in effectiveness in accordance with conditions of life.

One phase which deserves the attention of applied psychology is the necessity of readjusting and adapting national habits, inherited

from pioneer times, to modern economic and social requirements. Our national habits of wastefulness and carelessness are the result of our inheritance from a time when the wealth of our resources seemed to be inexhaustible, and where this apparent inexhaustibleness permitted a lavish use and even waste of our resources for experimentation in an effort to develop these resources with feverish haste. This waste was frequently inevitable and excusable in view of our dearth of technical knowledge, our lack of experience, and the absence of any economic necessity for conserving our resources; the waste was perhaps greatest in the use of lumber and in metallurgical operations. Newspapers and magazines meanwhile were constantly dinning into the ears of the growing generation the self-deception that our resources were inexhaustible. The suggestion that resources should be conserved was derided as a miserliness which is unworthy of an American; and when, in 1869, the writer began to advocate the view that our mental resources, lying latent in the mass of people, should be developed by means of industrial education, he was derided as a crank not only by ignorant people but by business men and university graduates. It is no wonder, then, that the present generation is afflicted with habits of carelessness and wastefulness, and that the path of least resistance and the short-cut are chosen in an effort to 'get there' as rapidly as possible. The discovering of the best means to readjust or to eradicate these habits should be one of the aims of applied psychology.

The second phase which deserves our earnest attention has to do with the circumstance that the specialization of labor and the monotony of repetitive operations, mechanical and clerical, has an atrophying influence upon the mental activity and initiative of millions of workers in shops, stores and offices. Certain psychologists have claimed that no such atrophying effect results from the monotony of work. It is true that even the veteran tender of the automatic machine makes a superficial showing of intellectual ability and sprightliness unless he be naturally dull and stupid. But if these psychologists had observed that individual in his daily routine of life and work year after year, they would have noticed that he lacks initiative and is helpless when obliged to change his accustomed routine, and they would have observed that he is deficient in reasoning power and judgment when dealing with questions of public interest or questions which concern the relation of his work and his employer's business to his own job and the security of earning his bread and butter. They would have noticed his growing inability to grasp the import of municipal, state and national questions. Why do our educational and other public institutions produce such meagre results in the management of political and social affairs? Why does the demagogue still flourish? Why do we still have the 'pork barrel' with us? And why do the 'something-for-nothing' schemers still succeed in drawing big crowds? Let us see. The writer had a friend, a very intelligent mechanic, who failed in business and in a fit of discouragement enlisted in the army. He has told me of the expedients to which the soldiers in the Western forts resort in order to counteract the monotony of army life. They go out on the prairie, become intoxicated, fall asleep in the sage-brush and run the risk of being charged with desertion,—not for the sake of drinking but for the purpose of reviving their drooping, stagnant minds for a few hours. A superintendent of schools once asked the writer for a frank opinion concerning the efficiency of his schools; and the writer as frankly replied that although his schools were as good as others, yet in them as in others the children in the intermediate grades were becoming duller instead of brighter. That is, there were mental forces at work in these schools

which tended toward arrested mental development or atrophy of mind. And the superintendent admitted having noticed the same state of affairs. If this happens in the case of young and active minds,—and no one can deny that it does happen all over the country,—why should not the same atrophying forces exert an even stronger influence under the more disadvantageous conditions of 'set' and indifferent minds in shops, stores and offices?

When the writer was connected with the physical testing laboratory of the Pennsylvania Railroad, much of the preparing of the test pieces had to be done in the shops, sometimes as many as eight men being engaged in that work. Because of the nature of the work, good mechanics were assigned to it. Yet constant care was always necessary in order to insure the work being done properly, not because the men were not intelligent enough or skilled enough, but because it was difficult to get their minds out of the mental groove which had been cut by their unvarying daily routine. And it was difficult for them to obtain a mental picture of anything which lay outside of that routine. The writer has frequently had occasion to observe this groove-like working of the mind, even in men of literary and especially of purely technical education who are in consequence unable to grasp the larger, broader functions and relations of their occupations or of social life. Is there not a close relation between this desire and necessity to obtain a broader mental view, and the popularity of moving pictures which visualize life but require no mental effort on the part of the audience?

The third phase of the problem which must be solved by the assistance of applied psychology if it is to be solved at all, pertains to the struggle for supremacy between industrial autocracy and social democracy. The control of nature's laws by applied science and technique has created industrialism with its unavoidable concentration of corporate management and its unavoidable autocratic regime. The necessity of concentrating the management of the huge modern industrial and commercial organizations into the hands of a few, and of demanding of all within the organization that they shall submit to an almost military discipline would be the same under any form of political government, whether autocratic, aristocratic, oligarchic, democratic or socialistic. But the more the existing form of political government resembles the autocratic regime of industrial organization, the less likely is a conflict between the social forces and the industrial regime.

The autocratic political government and the autocratic industrial organization are alike in that they both exhibit feudalistic tendencies; and hence in an autocracy the masses of industrial workers are not affected by any essential differences between their social life and their political life. But in a democracy such as ours, there is constant liability of friction between the industrial organization and the social organization. The industrial organization rests upon a scientific basis, with experts as advisers and managers; democracy rejects expert knowledge and advice, claiming that popular intelligence is adequate for the management of the affairs of the commonwealth. But since corporate interests and public interests are co-existent and co-ordinate, they must have constant dealings with each other. Hence it frequently happens that corporate expert knowledge and popular government knowledge come into conflict; and the consequent reaction upon the public mind is unfavorable because the public has no faith in expert knowledge.

A more serious difference of opinion arises from the fact that the industrial organizations clamor for a more efficient education of the people, and from the fact that the inefficient democracy is reluctant to grant this demand, alleging that such an education is unnecessary

and is beneficial only to the financial interests of the industrial organization. Then, too, the spirit of individualism and independence which is fostered and promoted by democracy is at variance with the autocratic regime and the military discipline of the industrial organization; this conflict produces a condition of life both inside and outside the works which is not contemplated with favor by the employees, however willing they may be to submit in order to earn a livelihood.

But worst of all, and productive of most ill-will and misunderstanding between corporate industry and the populace, is the frequent display of feudalistic tendencies on the part of the corporations,—in their endeavor to guide the social, the spiritual, the ethical and the educational life of the people of the community. The object of this endeavor is always philanthropic and praiseworthy in so far as it aims either to give to the employees and their dependents the benefits of organized guidance by experts, or to cultivate a sense of corporate loyalty by dispensing feudalistic benevolence. But in modern times, when contract is the only relation which is recognized between employer and employee, contract relation and feudal relation can not co-exist without generating friction and misunderstanding. Feudalism received its sanction and strength from the personal relation and the mutual responsibility between feudal lord and retainer,—the feudal lord furnishing protection and security of status, while the retainer gave service in return, these mutual ties of protection, benevolence and service existing for life and extending over the community as a proprietary right and duty. This, however, does not mean that corporate industrial organizations should not concern themselves with public welfare in their own interest and in the interest of their employees, nor that they should not lend their expert knowledge for that purpose. All the ethical, political, social, educational and economic group-interests in a community are so intimately interwoven that they can not be separated without injury to some or all of the groups. Hence all social forces in a community should co-operate to the extent of their ability for the purpose of fostering their mutual interests. But if any one group or interest should step out of that co-operative circle, and if it should, directly or indirectly, assume the control or direction of those educational, ethical or social forces which in a democracy are matters of public concern, such an action will inevitably create a feeling of resentment, and a conviction that however well-meant the endeavor, it constitutes an encroachment upon democratic freedom and personal liberty.

If an interest which thus acts in a spirit of benevolence possesses the power of employment, and if from an entirely benevolent motive it claims the right of thus guiding and guarding not only the industrial but also the social and ethical interests of the employees, then the action becomes feudalistic. It clashes with the established democratic institution, producing fear and mental and civic inactivity on the one hand, and on the other hand, creating an under-current of antagonism against such measures as are just, timely and really helpful. The situation is analogous to one where in fighting a forest fire one group of fire-fighters pushes the others back, being convinced that mentally the latter are not so well-equipped although physically quite as strong. Under such circumstances the rejected group would stand back sullenly and give only half-hearted or no assistance. But if the superior group were helping to educate the inferior group in the art of fire-fighting, and should do so in a spirit of co-operation, team-work and good-will would result instead of resentment.

Summing up the influences of the modern industrial organization upon the equally modern democratic social organization, we find that

the former reacts unfavorably upon the latter in certain ways: The expert economic management is distasteful to inefficient democratic management; the unavoidable military factory regime and discipline exaggerates democratic freedom; the demand for ever-increasing efficiency makes undue demands upon our undeveloped and neglected mental resources; and the feudalistic tendencies which attempt to hitch democracy to the personal service of industrial autocracy are all at variance with our inherited spirit of excessive individualism and with the spirit of our political institutions. The result is misunderstanding, distrust, lack of harmony, hindrance to progress, abuse of talent, and waste of mental and material resources. The more exacting the restraint which is necessary within the shop gate, the greater is the desire to revel in democratic freedom outside the shop gate. The restraining rules within the shop gate can not be broken without risk of loss of bread and butter; the civic restraint outside the shop gate is largely of the employee's own making. And it is small wonder if these civic restraints are often treated with indifference and are even brushed aside in consequence of the mental reaction from the effects of the industrial restraint. May not the growing mob-spirit be a manifestation of that mental reaction? In monarchical countries this phenomenon is better understood, and provision is made for public amusements and entertainments of various sorts in order to divert this reaction into safe channels. But democracy does not yet seem to have learned how to attack this psychological problem.

It is obvious that legislative enactments are insufficient educational agencies to cope with this serious problem. What we need is a change in our national habits and customs, in our mental and moral characteristics. And here is the opportunity for applied psychology to step into the breach in order to harmonize the contrast and antagonism between the industrial regime and the democratic regime.

The National Association of Corporation Schools is doing pioneer work in furthering this object. The apprentice schools and the various special schools maintained by the members of that Association within their establishments at their own expense, are conducted not only for the purpose of satisfying the vocational needs of the concern but also for the purpose of endeavoring to correlate and co-ordinate the vocational subject with the cultural and social economic life of the students of the outside world. In other words, they are endeavoring to socialize the schools in a way which is useful in that it prepares the student for the civic duties of his democratic environment without being feudal and benevolent. Upon this broader social-economic basis they can co-operate with the public school system for mutual benefit, the shop and commercial schools reacting encouragingly upon the public schools, while the latter furnish better preparation in return. And with the introduction of corporation or employers' continuation schools, this sphere of educational and social usefulness of corporation schools will be widened because not only do continuation schools reach larger numbers than the purely special schools, but since the training in the continuation schools is not specific but tends rather to develop general intelligence, these schools serve, at least in part, to bridge the gulf between the exacting demands of industrialism and the public demands of democracy.

HUGO MÜNSTERBERG: IN MEMORIAM

By WILLIAM STERN

(Translation from the *Zeitschrift für Pädagogische Psychologie und Experimentelle Pädagogik*, Jan., Feb., 1917)

The science of psychology has again suffered a grievous loss. On Dec. 17, 1916, in his fifty-third year, Hugo Münsterberg was overtaken by death while lecturing. Thus even to his last breath he was unceasingly active, as unceasing work was a dominant quality of his character. Not the quiet work of the scientist's cell, but a far reaching public activity, the organization of the realms of politics and *Kultur*, the transference of scientific knowledge and methods to the demands of practical life—these, especially in recent years, had become the chief occupation of his life. But at the same time he was an investigator of penetrating sharpness, with a power of presentation marked by genius, and he was also a philosopher who had struggled most earnestly with the great problem of the theory of the universe (*Weltanschauung*). That he did not nevertheless always reach a full unification and harmony of its manifold features, that often enough indeed two souls fought within him, forms the tragedy of this personality.

This appears even in the fact that he was a man with two Fatherlands. He lived in Germany, where he was born in Danzig on June 1, 1863, through his apprenticeship years and also began there his mastership years. He studied in Leipsic, chiefly with Wundt, and in Heidelberg with Windelband; he obtained the doctorate in philosophy and in medicine; he was docent and professor extraordinary at Freiburg. In 1892 he took the authorized leave of absence for a few years in order to establish a psychological laboratory at Harvard University (Boston), the chief institution of higher learning in America, and there he remained till the end of his life, almost a quarter of a century. He was often in Germany, but always as a vacation traveler, or as in 1910-1911, as exchange professor at the University of Berlin. A permanent opening for work in the Fatherland, such as he himself silently longed for, did not come.

For many years Münsterberg considered it his special problem to strengthen the relations between his first and his second homelands. His books on America and the Americans, the founding of the American Institute in Berlin, his proposal to shape the Hamburg institution of higher learning as an embodiment of American University ideals, his share in the psychical organizing of German-Americans, as well as many other things, testify to this. He did not always find sympathy in these attempts either here or there. But at the beginning of the world war, his attitude became completely unambiguous and unconditional. He realized that he was a German, and regardless of consequences he began at once a spiritual war against the traditional English sentiment at Harvard. What this meant to him is shown in the following portion of a letter sent to me in February, 1916: "Day and night I work both before and behind the scenes, almost entirely in the interests of the political struggle, and fortunately thus I can

accomplish much. Of course almost all of my old relations are severed, especially here in Boston. Most of my friends here no longer recognize me; I have been thrown out of clubs and put out of academies. All their rage has concentrated upon me. But we hold out." The hope which he expressed in the same letter, "I hope I can soon see your institute, for it is our plan to take the first Hamburg steamer that crosses," will now never be fulfilled.

Scientifically also there were two souls in Münsterberg, which never were completely harmonized. As a psychologist, especially in the first period of his investigating, he was most sharply oriented for natural science. Psychology has to do with the contents of consciousness as objects of factual consideration, with their analysis into simple elements bound together by causal laws, and with their resolution into the accompanying physiological phenomena. When man is "psychologically" explained he ceases to be a personality. There are then no inner purposes and attitudes, no significant totality or vital value, but only psychical elements, which are related to one another and to the physical according to regular laws. But on the other hand, Münsterberg is very far from denying the correctness of that other point of view; he even thinks it the truer and higher, only lying outside of all psychology. Philosophically he professed himself an idealist, in which his inner relation to the Baden group, Windelband, Ricker, J. Cohn, appears, but with an especial inclination to Fichte. His *Weltanschauung* was constructed upon a theory of value which is completely independent of the causal considerations of natural science. In it there is no longer question of cause and effect but only of end and norm. Here man is not the object of analytical knowledge but the subject of a unified attitude. Here life is not a mechanical natural process but a significant relating of purposes.

Thus the outcome is a two-world theory which leaves unsatisfied the yearning of man for a final unity, and yet only where unity is, is there a true *Weltanschauung*. To me Münsterberg seems here to be the typical representative of a period of transition. The insight had awakened that a psychology which is only an analysis of consciousness does not do justice to the value of personality, but the determination was still lacking to reform psychology from the ground up so that it could also do justice to the theory of personality. What must come is a personalistic psychology.[1]

The sharp separation of the psychological investigation of facts and the ethical theory of ends also found in Münsterberg a formulation important pedagogically, which one must agree with in its fundamental ideas in spite of other differences of opinion. Münsterberg fought with zeal a false "psychologism" in the teacher. Wherever a man has actual dealings with other men, and so especially in teaching, he must evaluate unitary subjects, he must strengthen personalities in process of development, but not explain the contents of their consciousness. He who forgets this runs the danger of neglecting the ethical problem. The teacher who has to do only with psychology in all his educating, easily considers his pupils as mere samples of interesting psychical phenomena; he also feels himself easily lured off to deducing the purpose of education from the psychological conditions, while these furnish only the means by which ends sanctioned on far other grounds can be attained. This warning of Münsterberg against overmuch preoccupation with psychology aroused in its time much surprise and contradiction among teachers. One can only

[1] Perhaps I may mention here that just this sharp formulation of the split in Münsterberg was the determining factor for me to transfer the views of personalism to psychology also.

completely evaluate it from the background of the American situation. In fact, there seems to have been for some time a very one sided cult with psychological experiments as the chief object of the teacher's training; perhaps a protest against it was not entirely unjustified.

But naturally Münsterberg's positive work in the field of psychology is far more important. In the first period of his theoretical investigation we must mention especially the theory of the will (in which he reduces the will to an aggregate of sensations and muscular tensions) as well as the *Aktionstheorie* connected with it, which also ramifies into the realm of pedagogical-psychological interests. According to this the elementary, primitive form of the psychical life is not the sensation or idea, that is, a passive given, but the immediate unity of impression and expression, of sensation and muscular movement. The entire modern basal principle of self activity, the work principle, etc., is related to this idea expressed by Münsterberg more than two decades ago. That originally he tended to overvalue the purely muscular factor we must refer to the newness of the thought.

But more and more his interest in psychological theory was replaced by one in applied psychology, and here his universalistic spirit, participating in the manifold ramifications of *Kultur*, stands revealed. During the years when we in Germany had only cautiously and tentatively begun to shape methods for the new problems of application, Münsterberg had penetrated into the fullness of human life, had laid down a general program, and in four books of his own had given a wide outlook into the possibility of making psychology effective in the administration of justice, the healing of the sick, education and industrial life. It is true that often he showed more boldness and power to image future possibilities than he did cautious technical knowledge, but much greater than this is the service which he did of attracting publicity (even non-psychological) to this perfectly new method of controlling *Kultur*, and of drawing the great guiding lines for future work. Most of all is his work path-breaking on the Psychology of Industrial Life. In this he describes the American Taylor system of scientific management, on its psychological side, and presents his now notable experiments on the vocational selection of street-car conductors and telephone operators. Here he gave the impetus to the attempts which are now also introduced into Germany, to make vocational choices from a psychological point of view.

In his last great work, Psychotechnik, Münsterberg gives a unified presentation of the various possibilities of applied psychology. Perhaps the educator will not find overmuch that is new in the section on education, for the study of children was somewhat aside from Münsterberg's interests. Of far more service will be the section on industrial life, especially the general part, which gives an attractive presentation of the significance of psychotechnics in general and of its two chief ends, psychological prediction and psychological control.

In Münsterberg psychology loses one of its most important leaders and most stimulating thinkers, whose thoughts will fructify both theory and practice long after his premature death.

Münsterberg's chief scientific German works are the following (all published by J. A. Barth, Leipzig): Beiträge zur Exper. Psychologie, 1889; Grundzüge der Psychologie, I, 1900; Philosophie der Werte, 1908; Psychologie und Wirtschaftsleben, 1912; Grundzüge der Psychotechnik, 1914. In addition he published a number of works in English. The works from his laboratory appear in the Harvard Psychological Studies.

BOOK REVIEWS AND NOTICES

ROBERT M. YERKES, JAMES W. BRIDGES and ROSE S. HARDWICK. *A Point Scale for Measuring Mental Ability.* Baltimore: Warwick and York, Inc., 1915. Pp. viii+168.

In the fall of 1913, Yerkes proposed to Bridges that they should cooperate in an attempt to construct a measuring scale for intellectual ability which should consist of a single series of tests, in connection with which credit should be given according to a graduated scale of one hundred subdivisions. The present volume offers the results of this endeavor.

In Part I Hardwick gives a general description and the relations of the Point Scale. The twenty tests, arranged for the sake of convenience approximately in the order of their difficulty, are designed to cover various forms of the principal mental functions, such as perception, discrimination, motor coördination, association, memory, imagination, etc. The point method of scoring according to the merit of the subject's response has many advantages over the 'all-or-none' principle. It brings out the full value of the testing material, and thus gives a far more complete and detailed account of the individual from the psychological point of view without increasing the expenditure of time and energy. One hundred is the maximum score. Hence if an individual obtains a total of 70 points, and the norm for a group of his own age, sex, race and social condition is 80, the degree of his retardation is expressed in graduated terms. Following a detailed description of the method of using the scale, Hardwick discusses the relation of the Point Scale to the Binet Simon Scale. There are two chief points of departure between the two scales: Firstly, the age arrangement of the Binet Scale assumes that the mental development of all normal individuals proceeds by similar stages, that the correlation between different functions is the same for all individuals at a given stage, and that each stage of mental development corresponds, in turn, to a certain physical age. The originators of the Point Scale question the validity of this assumption. Secondly, by the Binet method of scoring, the subject either fails or succeeds. Degrees of failure or success are not taken into consideration. This is eminently unfair to the examinee.

In Part II Yerkes and Bridges present the results of the application of the Point Scale to 805 individuals: 675 pupils of a city grammar school located in a medium to poor region and including grades from the kindergarten to the eighth, inclusive; 54 kindergarten and first grade pupils of a grammar school located in a good neighborhood; and 76 adults ranging in age from seventeen to forty-three years. In analyzing the results of these examinations, many factors which have a bearing on the individual's score become apparent. Norms for age, sex, linguistic and social status are calculated on the basis of the statistics at hand. The tremendous importance of obtaining as much information as possible concerning the life history of the individual to be tested is repeatedly emphasized by the authors. By taking 675 of the pupils and the 76 adults, irrespective of language or sex differences, the age norms of the following table are obtained:

Age	4	5	6	7	8	9	10	11	12	13	14	15	Adult
Number Tested.	5	39	71	73	61	74	76	79	60	60	52	25	76
Score	14	22	29	34	39	52	59	64	74	74	78	77	91

It must be borne in mind that these norms, obtained as they are from an insufficient number of records, can not be accepted as final. For the present, however, they may be considered as fairly representative and are at least highly suggestive.

In Part III Hardwick gives a brief report on 155 hospital cases examined by the Point Scale. In Part IV Yerkes describes the Point Scale revised on the basis of the results already obtained with the original scale.

Descriptive Title of Test	Maximum credit
Aesthetic comparison and judgment	3
Perception and comparison of pictures (missing parts)	4
Comparison of lines and weights	3
Memory span for digits	5
Counting backward	4
Repetition of sentences	6
Description of three Binet pictures	9
Arranging cubes according to their weight	2
Comparison of the three pairs of objects	6
Definitions of concrete terms	8
Resistance of visual suggestion	3
Copying of simple geometrical figures	4
Free association	4
The use of three given words in one sentence	4
Comprehension of questions	8
Drawing designs from memory	4
Criticisms of absurd statements	5
Construction of sentences	6
Definitions of abstract terms	6
Analogies	6
Total	100

Having obtained the Point Scale score for a given individual, there are various ways of expressing the relation of the score actually achieved to the expected score or norm. There are four expressions which Yerkes considers useful in reporting the result of an examination. These are: (1) The Point Scale score; (2) the mental age; (3) the mental status; and (4) the coefficient of intellectual ability (Point Scale score divided by norm). For example, if a six-year-old English-speaking boy obtains a score of 25, his coefficient of intellectual ability is 25 divided by 29 (norm of the English-speaking group of males six years old) or .86. Twenty-five points is the average for a boy 5.5 years of age. Hence this individual is .5 year below age. His values, then, are: Score, 25 points; mental age, 5.5 years; mental status, —.5 years; coefficient of intellectual ability, .86.

Yerkes is convinced that the Point Scale, in spite of a number of serious defects, is much superior to the Binet-Simon Scale. Yerkes proposes to develop what may be called a Universal Point Scale, in which the principles of a single series of measurements, graded with respect to difficulty, and of credit according to merit, shall be so used that individuals ranging in age from three years through maturity may be measured with equal satisfaction, and their mental status expressed not partially as, for example, in terms of intellectual ability, but, more completely, by means of an equation which shall include affectivity as well as the other principal mental functions.

Clark University. CARROLL C. PRATT.

LEWIS M. TERMAN, *The Measurement of Intelligence*. Boston: Houghton Mifflin Co., 1916. Pp. viii+362.

Before any satisfactory reform of the many evils prevalent in our educational system can be expected, the existence and significance of the many differences in mental endowment of school children must be taken into account. The school must adapt itself to the requirements demanded by the many grades of intelligence, ranging from idiocy on the one hand to genius on the other, which are brought to light by scientific diagnosis and classification. In the future, intelligence tests are certain to play an ever-increasing rôle as a basis for grading, for vocational guidance, and for diagnosing feeble-minded, delinquent and superior children. Many fallacies current among teachers, such as the over-estimating and the under-estimating of the intelligence of retarded and superior children, have been pointed out by Binet, who keenly felt the crying need of standardization. The particular merits of the Binet-Simon method of testing intelligence are: (1) The use of age standards; (2) the setting of problems which demand reason, ingenuity, judgments about abstract matters, etc., instead of attempting to measure sensory discrimination, mere retentiveness, rapidity of reaction and the like; and (3) the attempt to test 'general intelligence' rather than memory, attention, imagination, etc., which belong to 'structural' and not to dynamic psychology. Binet's conception of intelligence emphasizes three characteristics of the thought process: (1) Thinking tends to take and maintain a definite direction; (2) it is capable of making adaptations for the purpose of attaining a desired end; and (3) it possesses the power of autocriticism. The guiding principle with Binet was to find an arrangement of tests which would cause an average child of any given age to test 'at age,'—that is, the average five-year-old must show a mental age of five years.

It has been found that in many cases the average child does not test 'at age' on the Binet-Simon scale; and it was to remedy this defect and to create greater uniformity that Terman's Stanford revision and extension of the scale was made. The revision involved the examination of approximately 2,300 subjects, including 1,700 normal children, 200 defective and superior children, and more than 400 adults; it also involved the adopting of a method of scoring which would cause the normal mental age to coincide with the chronological age. That is, the scale should give an intelligence quotient (I Q) of unity, or one hundred per cent for unselected children of each age. Ninety tests were chosen for the final revision, or 36 more than the number included in the Binet 1911 scale. There are 6 tests at each age level from 3 to 10, 8 at 12, 6 at 14, 6 at 'average adult,' 6 at 'superior adult,' and 16 alternative tests. Terman offers the following suggestions for the classification of intelligence quotients:

I Q	Classification
Above 140	'Near' genius or genius
120-140	Very superior intelligence
110-120	Superior intelligence
90-110	Normal or average intelligence
80-90	Dullness, rarely classifiable as feeble-mindedness
70-80	Border-line deficiency, sometimes classifiable as dullness, often as feeble-mindedness
Below 70	Definite feeble-mindedness, morons (high, middle and low) and imbeciles

In discussing the cases analyzed, the author gives many facts of searching sociological and pedagogical import.

In Part II, Chapters VIII to XX, Terman gives a guide for the use of the Stanford revision and extension; formulates instructions for procedure in administering and scoring the tests at each age level; and suggests valuable hints for putting the youthful examinee at ease and arousing the desired interest in the task.

The author is of the opinion that conscientious practice will enable any intelligent and tactful person without psychological training to use the scale successfully. The clear and untechnical manner in which the book is written will make it of practical service not only to psychologists, but to teachers, physicians and social workers.

Clark University. CARROLL C. PRATT.

SAMUEL E. SPARLING. *Introduction to Business Organization.* New York, The Macmillan Co., 1916. Pp. xvi, 374.

The scope of this volume does not include business management, but attempts to bring together for the first time the various facts and principles upon which business is organized. "The first division is introductory, and is devoted to the classification of business activities, and especially to the legal aspects of business organization. The second division is devoted to a discussion of the principles of organization, the simplest forms of which are illustrated by a chapter on farming, followed by three chapters on the organization of manufacturing, and by several chapters on the organization of distribution. Among the subjects treated here are exchanges, direct selling, wholesaling and retailing, traveling salesmanship, the mail-order business, credits, collections, and advertising. . . . The purely social and economic phases have been passed over, except in so far as they threw light upon the problems of organization." The psychological aspects of the subject have received only a very modest general recognition in so far as they are barely hinted at in calling attention to the difficulties of selecting the administrative and labor forces and to the problems of appeal through improved advertising. But even here the author says that "while a great deal has been done to systematize the data and facts in regard to advertising, it cannot, however, be termed a science. All that can be said is that it is better understood to-day than it was a few years ago." The book contains no references to the literature, is written in a simple style, and seems to be well suited for young men entering upon a business career or upon a study of its underlying principles.

Educational measurements. By DANIEL STARCH. New York, Macmillan Co., 1916. 202 p.

After discussing marks as a measure of school work, and giving a sample survey of the marking system of a high school, the author gives a chapter each upon measuring ability in reading, writing, spelling, grammar, arithmetic, composition, drawing, Latin, German, French, physics, with a final chapter on the use of standard tests in school experiments, and a bibliography at the end. This is the best, as the latest ought to be, of its kind.

The following books and pamphlets have been received:[1]

WILLIAM A. WHITE. *Mechanisms of character formation. An introduction to Psychoanalysis.* The Macmillan Co., New York, 1916.

[1] Mention here does not preclude further comment.

HARRY D. KITSON. *How to use your mind.* J. B. Lippincott, Philadelphia, 1916.

NORBERT J. MELVILLE. *Standard method of testing juvenile mentality. With an introduction by William Healy.* J. B. Lippincott Co., Philadelphia, 1917.

WILLIAM HENRY PYLE. *A manual for the mental and physical examination of school children.* University of Missouri Bulletin, vol. 17, No. 24, Extension series 21. Columbia, Mo. September 1916.

FREDERICK S. BREED and F. W. FROSTIC. *A scale for measuring the general merit of English composition in the sixth grade.* Reprinted from *The Elementary School Journal,* vol. 17, No. 5, January 1917.

—— ——. *Note on the relation of legibility and form in handwriting.* Reprinted from *School and Society,* vol. 4, No. 101, Dec. 2, 1916.

WALTER B. SWIFT. *The developmental psychology of stuttering.* Reprinted from *The Journal of Abnormal Psychology,* Oct.-Nov., 1916.

NATIONAL SOCIETY FOR THE PROMOTION OF INDUSTRIAL EDUCATION, Bull. 25. *What is the Smith-Hughes bill providing federal grants to vocational education?* and *What must a State do to take advantage of the federal vocational education law?* Issued March 1917. 140 West 42d street, New York City.

—— ——. Bull. 19. *The selection and training of teachers for State-aided industrial schools.* (Revised edition.) Issued Feb. 1917.

ALFRED ADLER. *Study of organ inferiority and its psychical compensation.* Authorized translation by Smith Ely Jelliffe. Nervous and Mental Disease Monograph Series No. 24. New York, 1917.

Mental Hygiene, Vol. 1, No. 1, January 1917. Publ. quarterly by The National Committee for Mental Hygiene, Inc., Concord, N. H.

Journal of Delinquency, Vol. II, No. —, March 1917. Published bimonthly by Whittier State School, Department of Research, Whittier, Calif.

Kentucky High School Quarterly. April 1917.

APPLIED PSYCHOLOGY AT THE CARNEGIE INSTITUTE OF TECHNOLOGY. *Abstract from the Second Annual Report of the Division of Applied Psychology, including the Department for the Training of Teachers and the Bureau of Mental Tests.* Reprinted from the Fourteenth Annual Report of the Director of the Carnegie Institute of Technology for the year ending March 31, 1917.

SUMMARIES

LORLE IDA STECHER. *The effect of humidity on nervousness and on general efficiency. Arch. of Psych.*, No. 38, Dec. 1916.

This monograph is a part of an extensive study of the influence of air conditions on human beings conducted by the New York State Commission on Ventilation and reviewed by us in the previous issue of this Journal, pp. 94f. The present author, in chapter I, begins with a "History of Investigations of the Effect of Indoor and Outdoor Atmospheric Conditions," reviews briefly the three main classes of theories held during the nineteenth century, viz., the oxygen and the carbon dioxide theories, the organic poison theory, and the heat and humidity theory, she then gives a survey of the ventilation experiments carried on during the last thirty years in various countries, and finally summarises recent empirical studies by Dexter and by Ellsworth Huntington of the effect of climate on human welfare and efficiency. In the second chapter her own methods and experiments are described, which were planned and carried on, like those previously reviewed, under Thorndike's direction.

The degrees of humidity investigated in the present series were 50, 45, 37, 33, 32, 22, 21, and 20%, while the temperature remained constant at 75°F. Eight squads of four girls each, 17-18 years of age, recently graduated from the commercial department of a New York city high-school, acted as subjects. All conditions were kept as nearly constant as possible and various precautions were taken to control variable factors; for example, all subjects were paid for their services and received a dietetic midday luncheon of 1,000 calories per person per meal. The actual tests used were "(1) The purely physiological observations of pulse, temperature, and eye tremor, (2) The tests of efficiency in mental performances, such as addition and mental multiplication, (3) The tests of motor control and co-ordination," namely the three-hole aiming test, the hand-steadiness test for one minute, tapping for one minute, typewriting for ten minutes, an arm-steadiness test for two minutes, a simplified mirror tracing of a ten-pointed star, and an industrial fatigue test of five minutes duration. In addition to these tests, each subject had to indicate at the end of the three-hour morning session her degree of comfort according to an arbitrarily determined scale of five points, and her estimate of the temperature and of the moisture in the experimental room according to two similar scales.

The results as to the effect of humidity were just as negative as those previously reviewed. "The practical situation is that experimental humidity conditions considerably more rigorous than those obtaining in any artificially heated apartment show no demonstrable effect in behavior. . . . It must be remembered that in isolating the factor of humidity, we did not attempt to reproduce the conditions that go to make up a crowded, ill-smelling and excessively hot room. The very fact that the method of ventilating the experimental chamber produced a normal amount of air movement tended to alleviate the discomfort that would ordinarily be felt in a closed room under a 75°, 20% condition. . . . Whether this (general negative effect) is due to a real absence of harmful effects, or to the marvelous power of the human organism to adapt itself to a changed environment, is at present still a matter of speculation." The author has also com-

puted many correlations among the tests and found surprising differences from the results of previous computers. One chapter gives a discussion of the effects of practice and of the variations in efficiency during the working day which in the main confirm those of previous investigators. An appendix contains the complete instructions to the subjects and samples of the test-material used. L. R. G.

EDWARD WEBB. *Character and intelligence. Brit. Jour. of Psychol., Mono. Supplements,* Vol. I, 1915, ix+99.

The frequency and importance of judging character is tremendous in practical life. Nevertheless, character has been described as "a perfect jungle of psychological expressions of unknown (or little known) meaning." In literature only the man of unusual character has been treated. Most of the individuals in this world, however, are more or less 'average' and 'colorless.' Webb hopes to study these phenomena of an average group of individuals by means of statistical methods. He defines the terms which he is going to employ in the following way. "Intelligence may be taken as including those qualities which are specially related to abilities in mental performances, while under character it is usual to include the emotional and volitional—the social and moral qualities." "Character is thus, for our purpose, the sum of all personal qualities which are not distinctly intellectual." (p. 2.)

The subject of personal character has been frequently handled in the literature from two widely different points of view. 1. Abstract propositions have been put forward such as the classification of 'temperaments'; 2. .concrete judgments have been made acted upon by practical business men. Both viewpoints are marked by dogma and theory far in excess of the evidence put forward in their support. Although these analyses are not scientific in their treatment, we do find a few scientific studies which have preceded the present experiment. For example, Heymans and Wiersma attempted to establish a classification of types of character by the 'biographic' method,—by an analysis of the written lives of 110 of the leading men in the arts and sciences. They also employed the questionnaire method. Pearson tried to correlate estimates of general intelligence with estimates of a few mental qualities such as temper, popularity, shyness and the like. Ach and Barrett have approached a classification of temperaments from their experimental investigations of the will process. Stern advocates the use of the "psychogram,"—a complete, scientific mental analysis of an individual who has achieved success in one of the fields of human endeavor. But the actual results obtained by these investigators have contributed but very little to our understanding and analysis of this immensely interesting scientific and practical problem.

The subjects employed in the present investigation included two groups of male students, 98 and 96 in number respectively, in their second year of a training college in England; and also four groups of school-boys (average age of 12 years) in four different schools in London, numbering respectively 33, 35, 35 and 37. The judges who were to make estimates of these subjects, were 10 fellow students who had been elected Prefects for the year. These were chosen because they were able to study the subjects under all conditions,—in the class rooms, at social gatherings, at home and on the playing field. These judges were told to prepare themselves during the term by collecting evidence in order to write a general character sketch of each of their group during the Easter holiday. They were told to keep the strictest secrecy both with regard to the subjects and the other judges,

and they were also told to make their observations as wide as possible, noting *any* ability, habit or tendency for each subject. In the case of the school-boys, the teachers acted as judges.

A list of 39 qualities were adopted for investigation. These were divided into five general groups. 1. Emotions (such as tendency to be cheerful, liability to extreme depression, readiness to become angry and recover from anger, etc.). 2. Self Qualities (such as desire to excel, eagerness for admiration, superciliousness, belief in own powers, etc.). 3. Sociality (such as fondness for large or small social groups, impulsive kindness, trustworthiness, interest in religious beliefs, wideness of influence, tact, etc.). 4. Activity (such as extent of mental work bestowed on studies and pleasures, degree of bodily activity during business hours and games, tendency *not* to abandon tasks in the face of obstacles, etc.). 5. Intellect (such as profoundness and quickness of apprehension, soundness of common sense and originality of ideas). A somewhat shortened list was used for the groups of school-boys. Also certain tests of intelligence were given,—namely, paired words of opposite meaning, and the reconstruction of disarranged sentences. For the second group of students other tests of intelligence were added, which included tests of reasoning, comparison, problematic situations, definitions and paired opposites. The marking of the various qualities investigated was made numerically by the judges by giving grades from +3 to —3. In this scale zero indicated the average ability, +3 a very high degree of the quality, and —3 the very lowest degree.

The results obtained are given very extended treatment largely by means of Spearman's corrected formula for the coefficient of correlation. The reliability of the estimates and of the results are tested throughout. The reader is impressed with the great industry shown in the present study. An astoundingly great number of correlation coefficients have been calculated at what must have been a very great expenditure of time and energy.

Following the teachings of Spearman, Webb examines the results for evidence of a general factor of intellective energy. He finds what he believes to be definite and conclusive evidence that such a factor exists by correlating the different intellectual tests employed each with every other one. He then finds that all of the intelligence qualities as estimated by the judges "show good correlation" with this intellectual factor. This general factor has a low correlation with the groups of self qualities and sociality; while in the group of activities some of the qualities have a low, some a high and some a negative correlation. Many such correlations are made which we do not have the space here to consider in detail. But another example may be of value. The results show that Quick Apprehension is highly correlated with 1. a marked emotional temperament, 2. strong egoism, 3. the lighter social qualities, and 4. bodily activity and pursuit of pleasure. The estimates under Profound Apprehension are correlated with 1. a calm temperament, 2. much less egoism, 3. the deeper social qualities, and 4. mental activity and purposive performance of duty.

In a subsequent chapter, Webb puts forth the hypothesis that there is a general factor of character which corresponds for its own qualities in the same way that Spearman's general intellectual factor corresponds to the particular intellectual qualities. A statistical treatment of the data leads the author to find that there is such a general character factor present which shows itself in varying degrees for the different particular qualities. As the author puts it (p. 58) "That a second factor, of wide generality, exists; and that this factor is prominent on the 'character' side of mental activity (as distinguished from the

purely intellective side)." The author conceives "persistence of motives" "to be this general factor and that the particular moral and social virtues are derived from the more generalized quality." Some nine experimental studies from that of Müller and Pilzecker in 1900 to the work of Rath in 1914 are examined and analysed in the light of this hypothesis. Webb finds that his view is entirely in accord with that of Ach and at least not at variance with the other studies considered.

In a later chapter Webb considers the errors which are involved in making estimates of character qualities. These are of several sorts, inasmuch as, besides the random errors, there are several kinds of systematic errors. These latter may be due to a common bias in the mind of all observers or to the different observers taking different points of view. The author also includes two appendices in the text,—the first containing a synopsis of the mathematical formulae employed; and the second containing a selection of the reports of the judges as to what they understood by the terms used and what guided them in marking the subjects. A rather complete bibliography is appended.

From a consideration of these results Webb draws the following conclusions. He finds complete confirmation in his results of the hypothesis that there exists a general factor on the side of character which completely parallels the general factor of intelligence as advanced by Spearman and Hart. Estimates of the general factor of character are apt to be more pure measures than those of general intelligence. This general character factor "markedly dominates all the correlations yielded by the estimates of moral qualities, the deeper social virtues, perseverance and persistence; also, in the negative side, qualities related to instability of the emotions and the lighter side of sociality." The nature of this general factor of character "is best conceived—to be in some close relation to 'persistence of motives,' *i. e.* to depend upon the consistency of action resulting from deliberate volition, *i. e.* from will."

These are exceedingly interesting results and conclusions reported by Webb. There are several fundamental objections, however, which would appear to entirely invalidate this investigation. In the first place, Thomson[1] has shown in a recent paper that Spearman's method of calculation of data which led to his conclusion of the existence of a general intellective factor,—a 'general ability' as against special abilities,—is open to the gravest criticism. Thomson attacks the concept on purely mathematical grounds but his reasoning would appear to be unquestionably accurate. If this be the case, Webb's calculations are open to precisely similar criticisms and his conclusions must fall with the general concept.

But even if the concept be true, we do not believe that Webb's results justify his conclusions. His correlation coefficients are usually much too small to be taken as more than indications of tendencies. Certainly one would hesitate to make them the basis of sweeping statements such as Webb has made. A single example will suffice. On page 40, the author states that "All the intelligence qualities show good correlation" with the general factor. The actual coefficients in these cases are: quickness of apprehension 0.53; profoundness of apprehension 0.56; common-sense 0.29; and originality of ideas 0.47. Hence no single coefficient in this group is as great as 0.60 and one is below 0.30. The theoretical work with the correlation coefficient has shown that no value should be given significance, except as perhaps indication of a general tendency, if it falls below 0.75. Indeed the whole concept

[1] Godfrey H. Thomson. A Hierarchy without a General Factor. *Brit. Jour. of Psychol.*, VIII, 1916, 271-281.

of the correlation coefficient has recently fallen into more or less disrepute. It has been recognized that there are only a few sorts of data which may be properly treated by these means. The use of the coefficient of regression is to be recommended in its place.

Finally we would consider that Webb's method of obtaining his original data is open to suspicion if not to question. We think it doubtful if a group of young men and boys are capable of giving proper estimates of their fellow students with regard to the various qualities of intellect and of character such as were required of them. Webb speaks enthusiastically of the co-operation of these judges but we are not willing to accept the ability of such a group to make an accurate, unbiased and successful estimate of the various qualities which were required under the instructions.

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J. E. A. WALLIN, Director of Psycho-Educational Clinic, St. Louis. Annual Report, as part of the Sixty-Second Annual Report of Education of the City of St. Louis, Missouri, for the year ending June 30, 1916, pp. 144-211.

The first part of this report, pp. 144-174, gives general data on census retardates which contain several important items of a wider than local significance. Among the ca. 90,000 pupils in the public schools there were 1,861 or 2.5% retardations, which is less than in other cities of similar size. As to the prevalence of feeble-minded children in the schools. Dr. Wallin agrees with Dr. W. S. Cornell of Philadelphia and Dr. D. P. MacMillan of Chicago that their frequence is .5%. He recommends among others special "speech corrective work" on a large scale with specially trained teachers to handle these cases, special classes for children who, while not blind, have seriously impaired vision which cannot be corrected by glasses, and similar classes for defects in hearing; but blind and deaf children should not be admitted to such classes.

The second part of the report is a study of speech defectives, which constituted about 2.8% of the total enrollment. This figure slightly exceeds the range of other large cities in this country. The boys show a prevalence of 3.6% against only .2% of the girls, and this difference is especially marked in the stutterers. Dr. Wallin says that his "results do not justify the widespread fear that training left-handed children to write with the right hand will cause the development of speech-defects." He also finds that speech-defects "were almost twice as prevalent among the colored as among the white children." but that the sex differences among the former are not quite so strong. A most significant fact is the high percentage of speech defectives among the mentally defective children, which was at least ten times as high in the special schools for retardates as in the white elementary schools. "In general, the lower the grade of intelligence of the group the greater the prevalence of speech defects. . . . Indistinct articulation is distinctly more prevalent among the mental defectives, while stuttering is more prevalent among the normal, retarded, and backward children than among the defectives." It is also interesting to notice that over 80% of the stutterres and 96% of the lispers manifested their defects before the age of six. There are relatively more stutterers among the colored than among the white children in every grade except the kindergarten and the fourth high school year." Speech defects have a definite relation to school retardation, since children with such troubles often are very sensitive and rather do not answer than expose themselves to ridicule and impatience. Such re-

tardation is more marked with the stutterers than with the lispers and with the boys more than with the girls. Dr. Wallin concludes that "the correction of stuttering, lisping and some of the other remediable speech defects is just as truly a legitimate function of the public schools as the correction of faulty posture by means of physical training the mitigation of mental deficiency by means of individualized and differentiated instruction, the combating of phthisis through a special regimen in an open air school, or indeed the combating of illiteracy by providing instruction in reading, writing, and ciphering" and it is well recognized as such in Europe and in some of the larger cities in the United States. L. R. G.